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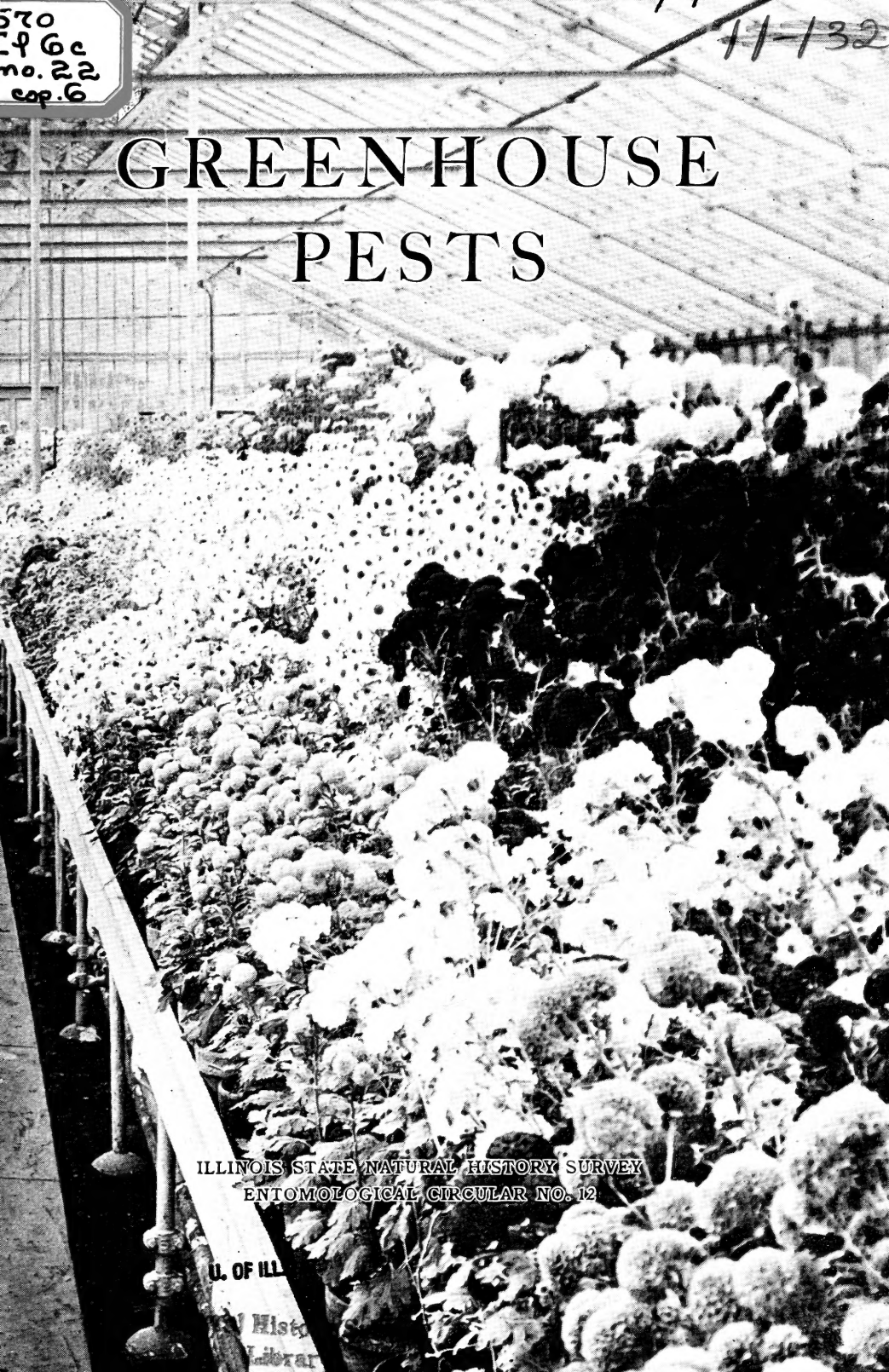
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GREENHOUSE PESTS



ILLINOIS STATE NATURAL HISTORY SURVEY
ENTOMOLOGICAL CIRCULAR NO. 12

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STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
STATE NATURAL HISTORY SURVEY DIVISION

STEPHEN A. FORBES, Chief

Entomological Series
Circular No. 12

Greenhouse Pests

A Manual of Practice in the Control of Insects and
Other Pests Attacking Ornamental Plants and
Flowers Grown under Glass in Illinois

BY

CHARLES C. COMPTON



Printed by Authority of the State of Illinois

URBANA, ILLINOIS

1930

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EXPLANATORY NOTE

Part One (pages 7-14) is an introductory discussion of the insect problems that confront the floricultural industry in Illinois and of the general principles on which most efforts to solve these problems are based.

Part Two (pages 15-101) deals individually with the harmful insects and other pests against which the florists in this state have to contend. The crops grown in greenhouses are arranged in alphabetical order, as shown in the following *Index to Names of Crops*, and the pests attacking each crop are listed under it, also in alphabetical order, their common names being used for this purpose and their scientific names being given in footnotes. Numerous illustrations are included, to show the appearance of the pests and examples of their work.

Part Three (pages 102-111), on fumigants, insecticides, and appliances, contains general directions for the use of the control measures recommended in **PART TWO** for the protection of each crop against its pests.

An *Index to Common Names of Pests* will be found on page 111.

For further information on any pest, the greenhouse operator is invited to communicate directly with the entomologists of the State Natural History Survey at Urbana, who are always glad to help the operator in any way they can, particularly in the identifying of insects and in the improving of control methods. Whenever there is any doubt about the identity of a pest, specimens of it and also of the injured parts of the plants should be supplied. The best way to send these specimens is in tin boxes or mailing tubes. If enclosed in envelopes, they are very likely to be smashed in the mail and mutilated beyond recognition. Every effort is made by the entomologists to render this service as promptly as possible.

This manual is being issued at present in a limited edition, for it is to be revised—to keep pace with advances in entomology and in greenhouse practice—and reissued with better illustrations of some of the pests and their work. Florists can be of great assistance by offering corrections and suggestions.

It is planned to issue a separate circular on the subject of pests attacking *vegetable* crops grown under glass, which are omitted here so as not to make the present circular too bulky.

ACKNOWLEDGMENTS

New recommendations given in this manual are based upon research in the control of insects conducted under the direct supervision of W. P. Flint, Chief Entomologist of the State Natural History Survey. Some of the experiments were conducted in greenhouses of the University of Illinois with the active cooperation of the Department of Floriculture. Professors H. B. Dörner, F. F. Weinard, and S. W. Hall, of that department, also aided in the preparation of the manuscript and the reading of the printer's proofs.

The following growers have aided in the research work by providing both space and plants for experimental purposes, often at a sacrifice of considerable time and money: Otto H. Amling, George J. Ball, John Baur, John Fischer, Carl Hausermann, Hans Jepson, Poehlmann Bros., F. C. Schaefer, A. Washburn & Sons, and others.

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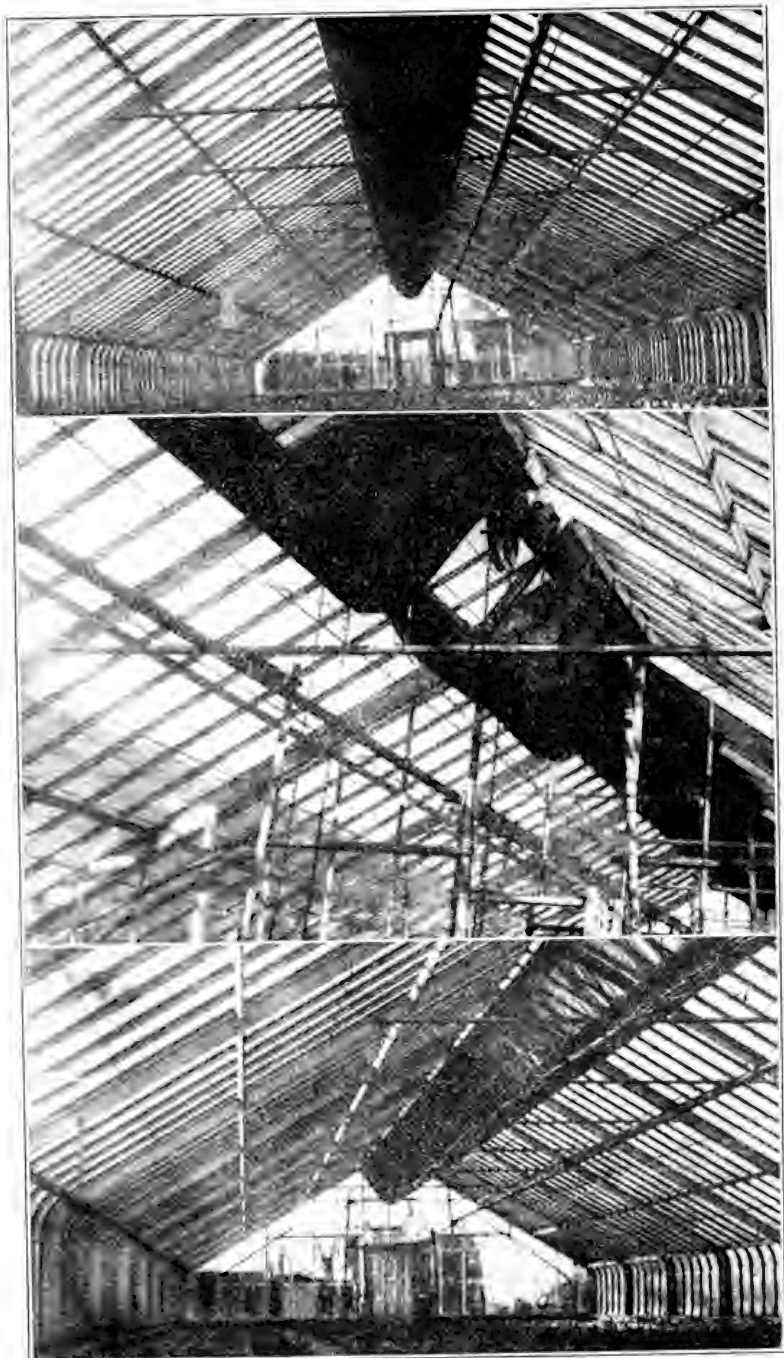


Fig. 1. Screened ventilators used in propagating houses in Illinois to aid in keeping out insect pests.

PART ONE

THE INSECT PROBLEM IN THE GREENHOUSE

Floriculture in Illinois is an industry of considerable magnitude. From a small beginning in 1845, when the first greenhouse in the state, a 50-foot lean-to, was erected on the site now occupied by the Chicago post office, the industry has developed more or less steadily—keeping pace with the increase in population and wealth in the Chicago region and throughout the state—until at present the total area under glass exceeds 20,000,000 square feet, or more than 460 acres devoted to the production of flowers and ornamental plants. The actual investment in greenhouses alone (exclusive of the value of the land) is estimated at \$20,000,000 and the crops grown in them are valued at more than \$20,000,000 a year. These facts easily place Illinois as the leading floricultural state in the country.

The chief center of the industry is in Cook County, where 70% of the total area under glass in the state is said to be located. Other large centers are at Pana, Lincoln, and Rock Island; and smaller centers are widely scattered, for every town of more than a few thousand population has at least one greenhouse establishment.

Roses, chrysanthemums, carnations, and sweet peas are the major flower crops, roses alone making up about half of the cut-flower trade. The minor crops, however, are always increasing in number and importance, to meet the modern demand for variety and novelty.

DAMAGE DONE BY PESTS

Along with the growth of the industry there has been an increase in the damage done by insects. Many pests that once were of only local importance, such as the CHRYSANTHEMUM MIDGE and the ROSE MIDGE, have become generally distributed over the state and have proved very destructive. The CYCLAMEN MITE, which was practically unknown a few years ago, now causes an average loss of 20% of the whole cyclamen crop. One grower in the Chicago district has lost as many as 200,000 plants in a single year as a result of the work of this one pest. New problems have been presented by the introduction of alien pests, such as the BULB FLIES and various SCALE INSECTS which have been brought into Illinois from time to time and have occasioned heavy losses to purchasers of infested stock. A new MEALYBUG has recently become established in Illinois and threatens to become one of the

major pests of chrysanthemums. Moreover, native pests, including several species of APHIDS, THRIPS, MEALYBUGS, ROOT WORMS, and SYMPHYLIDS, have been adopting cultivated crops in preference to their natural, or wild, hosts. A recent pest of the latter kind is the SYMPHYLID known as the GARDEN CENTIPEDE. In one establishment near Chicago SYMPHYLIDS of this species caused the complete destruction of crops in 1928, resulting in a financial loss of \$16,000.

In the state as a whole, the total damage done by insects and other injurious forms of animal life is estimated at present to range from 10% to 25% of the value of all the flowers and ornamentals grown under glass. Assuming 15% as a fair average reduction, we can safely say that the annual crop would be worth \$3,000,000 more than it is now if the industry did not have to pay tribute to these pests.

No crop is without its pests, and some have a dozen or more, so that the grower must be on his guard day and night through the growing season and even throughout the year, in order to prevent all his profits from being literally eaten up by one or another of these insidious enemies. Now the roots are attacked, now the stems and leaves, and now the flowers themselves. Sometimes only a few plants may be injured; again a whole crop may be wiped out. It is probably true that no single operation in the greenhouse yields as large returns as that which checks the depredations of insects, since any one of the major pests would be able to destroy a crop, commercially, before it could be matured if no control measures were applied.

PURPOSE OF THIS MANUAL

In the face of such dangers it is necessary for the operator to have a knowledge of the insects and to make timely use of fumigants, sprays, and dusts. Efficiency requires that the methods in use against the established pests be constantly improved, that new methods be devised for use against the recent invaders, and that the cost of control operations be reduced as much as possible.

It is hoped that the information given in this manual will aid growers throughout Illinois in identifying and controlling whatever kinds of pests threaten their crops. This information is based on the practical results of investigations carried on during the past seven years at Urbana and in the Chicago district. Every pest described herein has been observed at work in Illinois greenhouses, and the control measures recommended have been successfully used by florists cooperating with the writer. Illinois has a unique history in regard to the study of insects, largely through the uninterrupted work of the state

entomologists during the past 60 years, and the writer has drawn freely upon the vast store of facts found in the records of their work. One paper in particular, a report on greenhouse insects by J. J. Davis, published in the 27th Report of the State Entomologist, 1912, has proved especially valuable in the preparation of this manual.

AIDS TO CONTROL OF PESTS

The cost of insect control in the greenhouse can be greatly reduced if more attention is paid to preventive measures, in addition to the general practice of applying insecticides and fumigants. The following matters are worthy of constant consideration from this point of view.

Exclusion. A number of pests can be kept out of the greenhouse more easily than they can be controlled after they are once inside. Always look for insects on plants transferred from the field and on plants received from other establishments or taken in as boarders. Do not accept plants with deformed, rolled, or tied leaves, or with blotchy, discolored leaves; nor those with swollen areas on stems and leaves, such as the galls caused by the *CHRYSANTHEMUM MIDGE*; nor those with deformed flower buds or streaked petals. Again, it is advisable to examine the under sides of the leaves with a hand lens in order to discover the eggs of mites and other pests not easily noticed by a general inspection. The roots, also, should be examined closely, for they may harbor *EELWORMS*, *ROOT APHIDS*, *SYMPHYLIDS*, etc.

When soil is to be brought into the greenhouse, the root systems of the various plants and weeds that have been growing in that soil should be carefully inspected for several kinds of pests: *GARDEN CENTIPEDES* may be observed running rapidly among these roots, seeking to hide themselves when exposed to the light. If the roots appear to have been chewed, *WHITE GRUBS* or *WIREWORMS* may be found in the soil. If the roots are swollen or hypertrophied, a closer examination of the crushed roots under the microscope may reveal the presence of *EELWORMS*. Finally, the use of the microscope or hand lens on samples of the soil from various parts of the field may reveal insects that would otherwise pass unnoticed.

A barren strip from ten to twenty feet wide, entirely encircling the greenhouse, is a great help in excluding insects, particularly those that otherwise would find breeding places there in grass or other vegetation. Some florists have found that it is a good investment to cover the ground with concrete for a distance of fifteen feet from the house. Very few, if any, insects will crawl across such a strip of bare ground

or concrete. Thus the invaders are limited to the flying forms, and these in turn may be excluded by screens.

Screened ventilators and doors, no doubt, will be standard equipment in greenhouses of the future. Wire screens with fourteen meshes to the inch will exclude LEAF TYERS, LEAF ROLLERS, TARNISHED PLANT BUGS, BEES, the adult forms of the CABBAGE LOOPER, the CORN EAR WORM, the STRAWBERRY ROOT WORM, and all CUTWORMS, as well as many APHIDS and some other insects. Any fixed screen over the ventilators, however, will collect and hold dirt unless some provision is made for cleaning. The study made of this problem up to the present time does not warrant making definite recommendations.

Extermination. Although the extermination of pests already entrenched in a greenhouse is often difficult and sometimes impossible while the crops are growing, heavy fumigation with cyanide when the house is empty will kill off all kinds of insects for the time being. Insects breed rapidly under the ideal conditions afforded to them in the greenhouse, so that simply reducing their numbers gives but temporary relief. The greatest possible thoroughness, therefore, is necessary in all efforts at extermination, whether cyanide or some other fumigant is used. (Directions for fumigation are given in Part Three of this circular.)

Sanitation. Many insects seek out trash and rubbish under the benches and sometimes even on the benches, as a place in which to hide while resting or changing from one stage to another. The removal of all such trash is an essential part of greenhouse sanitation. Similarly, weeds and discarded plants should not be allowed to grow under the benches or along the walks, because they often harbor pests. Standing pools of water, dripping gutters, and needlessly exposed steam pipes in close proximity to growing plants, not only make it difficult to maintain proper temperature and humidity, but also encourage the development of certain pests that thrive under very warm and moist conditions. The avoidance of these unsanitary nuisances will aid materially in the unrelenting campaign that must be carried on against the insect enemies of greenhouse crops.

Natural agencies, including climate, weather, diseases, parasites, etc., which play an important part in the abundance of insects in general, often aid the florist in ways he may not recognize because they are hard to trace. Generally speaking, the conditions within the greenhouse afford an ideal environment for the development and reproduction of insects. Nevertheless, whenever any injurious insect is abundant out-

doors, it is then much more likely to become a serious pest within the greenhouse than at other times. Climate and weather are very important in this respect, inasmuch as severe winters or successive periods of freezing and thawing make it very difficult for overwintering forms to survive, excessive rainfall or lack of rainfall may influence the abundance of other forms, and variations in temperature and humidity have definite effects on the abundance of most insects and on their rate of reproduction. Various diseases to which insects are subject may also reduce their abundance or interfere with their reproduction. Parasites and predators sometimes hold certain pests in check. In the greenhouse, however, the sprays, dusts, and fumigants that are used against the pests are often more effective against their parasites and predators. Consequently, the natural enemies of harmful insects are never numerous within the greenhouse with the exception of a few weeks or months in mid-summer and are usually of little avail in the control of the pests. At the present time an attempt is being made in Illinois to introduce into the greenhouse important insect parasites by artificial means.

BENEFICIAL INSECTS

There are several kinds of beneficial insects that deserve special attention here. The more important ones living as parasites and predators on the pests with which we are concerned have certain distinguishing characteristics and markings. The grower will do well to become acquainted with them and protect them whenever possible.

PREDATORS

A predator lives independently of its victims—during the intervals between meals—and feeds upon many insects during its period of development. The useful work of birds, toads, and several other higher forms of animals that eat harmful insects is well known. Among the many kinds of predatory insects the following are more or less effective as factors in the natural control of greenhouse pests:

Several species of LADYBIRD BEETLES,¹ sometimes called LADYBUGS, which are often seen crawling over plants infested with "GREENFLIES," or PLANT LICE, rank among the most important enemies of various pests. They feed on APHIDS, SCALES, and other small insects and on the eggs of larger insects. Most of these beetles are entirely beneficial and do not feed on plant tissue. They are smooth, oval beetles, up to $\frac{1}{4}$ inch long, quite easily recognized by their hemispherical shape and conspicuous markings. Their color may be red, brown, tan, or yellow

¹ Members of the family *Coccinellidae*.

with black spots; or black with red or yellow spots. The young, which also move about actively on the foliage, are none the less beneficial, although they usually are not recognized as friends by the florist. They are, of course, somewhat smaller than the adults, and they have six prominent legs on the fore part of the body, which is covered with wart-like swellings or with spines and is brightly marked with red or blue



Fig. 2. Adult and larva of ladybird beetle. They feed on small insects and the eggs of larger insects.

or yellow. A closer examination will show their rather prominent, pincer-like jaws. As one grower remarked when shown them for the first time, they "look like young alligators." Unfortunately, they also have parasites which feed upon them and destroy them.

Many species of SYRPHID FLIES² are beneficial because they also ravenously devour APHIDS.

The larvae of these flies are slug-like in appearance, having no distinct head or legs, and they grow to a length of $\frac{3}{4}$ inch. They are reddish to yellowish and are spotted or mottled with brown or black. Their bodies, which are fleshy, taper to a rather sharp point at the head. They are often seen in the midst of a colony of APHIDS. Each larva inserts its head into an APHID and often swings the fore part of its body around in the air with the APHID waving thereon. It thus sucks out the contents of the APHID's body and then attacks a fresh specimen, sometimes at the rate of one a minute. *Adult* SYRPHID FLIES are not easily identified by the casual observer and are neither beneficial as insect feeders nor harmful as plant feeders. They appear like bees, wasps, or flies of varying sizes, frequenting flowers where they feed

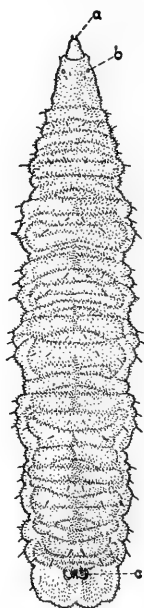


Fig. 3. Syrphid larva, greatly enlarged.

² Members of the family *Syrphidae*.

upon the nectar and pollen. Some species make a humming sound in flying, while others hover silently in one place in the air, suddenly darting away a short distance to resume their hovering. Not all species in this family prey on pests, but the slug-like larvae found in the midst of colonies of APHIDS, or "GREENFLIES," may be recognized as beneficial.

Other kinds of predatory insects that are of value to the greenhouse operator include a species of CENTIPEDE³ that holds injurious MILLIPEDES in check, various GROUND BEETLES⁴ that feed on some of the smaller CATERPILLARS in the fall of the year, and several APHID LIONS, or LACE-WING FLIES,⁵ that attack APHIDS. The eggs of these LACE-WING FLIES are supported on long, hair-like pedestals, and the larvae have the same general appearance as those of the LADYBIRD BEETLES.

PARASITES

Insect parasites, in general, are very small, and most of them live inside their victims, at least during their period of development. Sometimes as many as several thousand parasites of one kind emerge from a single host larvae that is little more than an inch long. Other parasites are external, living *on* their hosts instead of inside them.

There are many species of PARASITIC WASPS⁶ that attack harmful insects. Caterpillars parasitized by them may be recognized by their lifeless, contracted bodies, which bear marks where external parasites have fed upon them or where internal parasites have emerged from them, often with small white cocoons on their bodies or nearby. Parasitized APHIDS, or "GREENFLIES," may be recognized by their bloated, lifeless appearance, their uniform tan color, and the round exit holes in their backs caused by the emergence of the parasites. Besides APHIDS and the larvae of various LEAF TYERS and the CABBAGE LOOPER, other kinds of pests including CUTWORMS and SCALE INSECTS are held in check by these parasites, both inside and outside the greenhouse. Their work inside is of most value during the fall months. Briefly, their method of attack consists of laying one or more eggs in or on the body of the host. When the young hatch, they feed on the host, either externally or internally, and eventually kill it. For example, one species of BRACONID WASP⁷ is frequently effective in checking the larvae of the GREENHOUSE LEAF TYER in the fall months. The small, white cocoons of this useful species are readily seen within the folded leaves,

³ *Lithobius forficatus* L.

⁴ Members of the family *Carabidae*, particularly *Pterostichus permundus* Say, *P. lucublandus* Say, and some others.

⁵ Members of the family *Chrysopidae*.

⁶ Hymenoptera of several families, particularly the *Braconidae*, *Chalcididae*, and *Ichneumonidae*.

⁷ *Microgaster epagoges* Gahan.

usually near the dead and dried bodies of the LEAF TYER caterpillars. The tiny adults, however, after emerging from their cocoons, are easily killed by cyanide or nicotine fumigations, so that their effectiveness in the greenhouse is quickly brought to an end. Parasitic WASPS of the genus *Trichogramma* are being used in experimental work in Illinois for the control of several kinds of pests not only in fields and orchards but also in greenhouses.

POSSIBLE FUTURE PESTS

Fortunately, the EUROPEAN CORN BORER⁸ and the JAPANESE BEETLE,⁹ two widely advertised pests that have been recently introduced into the United States, are not likely to prove troublesome to florists in Illinois when they invade this State, for they have done practically no damage in greenhouses in regions where these pests have already become established. The CORN BORER has been known to attack chrysanthemum, gladiolus, zinnia, aster, dahlia, and a few other kinds of plants that belong in the list of greenhouse crops, but it has not shown much tendency to work under glass in other states and probably will not do so here. Neither does the JAPANESE BEETLE threaten to be of any importance as far as greenhouse crops are concerned, though it is almost omnivorous and has been reported to feed on ferns, cannas, zinnias, petunias, geraniums, violets, etc., in regions where it is abundant. It skeletonizes the leaves of many plants and chews the flower petals in much the same manner as our native ROSE CHAFER,¹⁰ but it is primarily a pest of nursery stock as far as the growing of ornamentals is concerned.

Many other insects, however, that are known in Europe, Asia, and other parts of the world might cause serious trouble to American florists if they were to become established here. Since there is constant danger that some of these foreign pests may be brought into this country accidentally, in spite of the most careful inspection of imported stock, florists need to be always on the lookout in order to apply control measures promptly enough to prevent the new invaders from becoming established. For this reason it is urgently recommended that any unknown or suspicious insect found to be causing damage in greenhouses in Illinois should be sent at once to the entomologists of the State Natural History Survey at Urbana.

⁸ *Pyrausta nubilalis* Hb.

⁹ *Popillia japonica* Newm.

¹⁰ *Macrodactylus subspinosus* Fab.

PART TWO

GREENHOUSE PESTS IN ILLINOIS

In the following alphabetical list of flowers and ornamental plants grown in greenhouses in Illinois, all the pests known to attack each crop are listed by their common names in alphabetical order, and each pest is discussed at some length under the crop on which it is normally most abundant and destructive. Each section dealing with a major crop is introduced by a brief statement of the relative importance of the several pests attacking that crop.

The discussion of each pest consists of three parts: first the *injury* done by the pest to the crop in question and to any other crops it attacks; second, the *control* measures recommended against it; and third, its *life history and habits*. This order of topics is followed because the grower most often notices the injury to the plants before he discovers the pests at work, and he usually wishes to know at once what can be done to control the pests. Since the successful use of control measures will often depend upon his understanding of the insect's way of living, he will be interested also in the notes on its life history and characteristic habits.

For the convenience of the reader, page references are given after the names of all pests that are listed but not described in connection with each crop, so that he may be guided directly to the discussion of these pests under the crops on which they are most often of major importance. The control measures recommended in each instance are applicable to other crops attacked by the same pest, unless otherwise stated.

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ADIANTHUM PESTS, *see* PALM PESTS, p. 66.

AGERATUM PESTS

Ageratum plants are subject to severe attack by WHITEFLIES, RED SPIDERS, and the GREENHOUSE LEAF TYER. The injury done by the WHITEFLIES is described below, together with recommendations for their control and notes on their life history and habits. The GREENHOUSE LEAF TYER and RED SPIDERS are discussed under chrysanthemum pests and rose pests, respectively, because they are more often found on those crops. Ageratums are also attacked at times by the CABBAGE LOOPER, CUTWORMS, and MEALYBUGS, and information on these pests will be found on the pages indicated by the numbers in the following list.

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Greenhouse Leaf Tyer.....	p. 39
Mealybugs	p. 50
Red Spiders	p. 75

WHITEFLIES

Among the many crops attacked by WHITEFLIES in greenhouses in Illinois, ageratum is usually the most seriously injured. Others often damaged are coleus, begonia, lantana, calendula, geranium, salvia, and fuchsia. None of these preferred food plants can safely be grown under glass in this state without the employment of measures to control WHITEFLIES. Of the several species found in greenhouses, the most common one is called the GREENHOUSE WHITEFLY,¹¹ and the others have practically the same appearance, life history, and habits, so that they need not be considered separately. The tiny, four-winged, powdery adults, about 1/16 inch long, are readily detected at rest on the under sides of the leaves. When disturbed, they fly for only short distances and settle down again immediately. If numerous, they rise in miniature white clouds. Close examination of the leaves will reveal the young—motionless, oval, flat, scale-like, pale-green larvae and pupae, less than 1/25 inch in length, with fine waxy threads of various lengths radiating from the body.

Injury. Both the adults and the larvae feed on the leaves by sucking the juices from them. Infested plants become yellowed, wilt, and finally die. The plants are also rendered unsightly because of the sticky substance that is excreted by the larvae and pupae. This substance is difficult to wash off, collects and holds dust and dirt, and

¹¹ *Trialeurodes vaporariorum* (Westw.).

affords ideal conditions for the development of sooty fungus, which forms black patches on the leaves.

Control. Repeated fumigation with cyanide is the best means of control of WHITEFLIES. Calcium cyanide, used at the rate of $\frac{1}{4}$ ounce to 1,000 cubic feet of space, will kill the adults in the average house. Since some houses are not as tight as others, it may be necessary to increase this amount somewhat. The immature stages, however, are very resistant to such dosages as the tender host plants will stand, so that one fumigation cannot be expected to eradicate these pests. Since they spend about two weeks in the pupal stage before they emerge as adults, the infested plants should be fumigated about every two weeks, or as soon as a new lot of flies appear and before they begin to lay their eggs. Directions for using cyanide will be found on pp. 102-105.



Fig. 4. Whiteflies on Gerbera. The powdery adults of this insect are recognized by most growers.

If cyanide cannot be used, the sprays recommended for the control of MEALYBUGS (p 50) will be found to have some value as a control measure, but spraying should not be relied upon to clean up an infestation.

Life History and Habits. WHITEFLIES are very prolific, each female laying more than 100 eggs, and a complete generation requires only 5 or 6 weeks. The eggs, which are scarcely visible to the naked eye, are attached to the under side

of the leaf by means of short stalks. They hatch in 10 to 14 days. The nymphs, or larvae, do not move from the leaf where they were hatched, but feed in one place for about a month, molting four times, and then becoming pupae. About two weeks later the adult flies emerge and begin egg-laying at once. The generations overlap, so that all the stages in the life history—eggs, larvae, and adults—may be found at one time on the same plant.

ALTERNANTHERA PESTS

Red Spiders	p. 75
Scale Insects infesting alternanthera belong chiefly to two species, the HEMISPHERICAL SCALE and the SOFT BROWN SCALE (p. 60).	
Thrips.....	p. 46

ALYSSUM PESTS, *see* SWEET ALYSSUM PESTS, p. 87.

AMARYLLIS PESTS, *see* BULB PESTS, p. 19.

ANTIRRHINUM PESTS, *see* SNAPDRAGON PESTS, p. 86.

ASPARAGUS PESTS

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Cutworms	p. 36
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ASPIDISTRA PESTS

Scale Insects	p. 59
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ASTER PESTS

Aphids, p. 89; <i>see also</i> Root Aphids.....	p. 94
Cutworms	p. 36
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AZALEA PESTS

Red Spiders	p. 75
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BEDDING PLANT PESTS

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BEGONIA PESTS

Cyclamen Mite	p. 38
Eelworms	p. 90
Mealybugs	p. 50
Whiteflies	p. 16

BULB PESTS

Bulbs of various kinds are subject to serious attack by one or both of the species of BULB FLIES described below, either of which is capable of destroying an entire crop. The greenhouse operator should exercise the greatest possible care in order to obtain clean bulbs, especially if he is not equipped to treat the bulbs he purchases. The following discussion of measures for the control of BULB FLIES and BULB MITES—the latter are also capable of destroying an entire crop—is necessarily brief. Additional information on the treatment of bulbs may be had by writing to the State Natural History Survey at Urbana, Illinois.

BULB FLIES

Narcissus, amaryllis, hyacinth, galtonia, and other bulbs fail to grow if they are infested by the NARCISSUS BULB FLY¹² or by the LESSER BULB FLY.¹³ These are pests of European origin, brought here in shipments of bulbs. They lay their eggs in the base of the leaves or in the necks of the bulbs, and the damage is done by their larvae, which are large, grayish, whitish, or yellowish maggots.

¹² *Merodon equestris* Fab.

¹³ *Eumerus strigatus* Fallen.

Injury. Each maggot, upon hatching, bores into the bulb, killing the flower bud and causing the whole bulb to decay and become soft. The outer scales of the bulb sometimes have brown scars.

Control. Other than taking every precaution to obtain healthy bulbs, there is little that the florist can accomplish in the way of control. All bulbs found to be infested should be destroyed at once. They usually can be culled out easily because they are lighter and softer than sound bulbs. Probably the most effective method of treating lightly infested bulbs consists of submerging them in water held at a temperature of 110-111.5°F. for 2½ hours. Cyanide fumigation is sometimes used.

Life History and Habits. The adult of the NARCISSUS BULB FLY is a shiny, yellow and black, hairy fly resembling a small bumble bee. Its larvae are thick and fat and grow to be ¾ inch long. The adult of the LESSER BULB FLY is blackish-green, almost hairless, and resembles a small wasp. Its larvae, which have a wrinkled appearance, do not exceed ½ inch in length. Several of the latter may often be found in a single bulb. Both species usually pupate inside the bulb, but sometimes in the soil also. There are only one or two generations in a year.

BULB MITES

Several species of very small, whitish MITES attack many kinds of bulbs and are particularly troublesome to growers of narcissus, hyacinth, tulip, Easter lily, and sometimes other bulb crops in Illinois. The HYACINTH BULB MITE,¹⁴ which has been most often found on bulbs received from foreign countries, is so small that it hardly can be seen without the aid of a magnifying lens, but it is capable of destroying an entire crop. A closely related species of MITE¹⁵ which is much larger and can easily be seen with the naked eye, commonly attacks Easter lilies, working inside the flower stalk several inches above the ground.

Injury. The infested bulbs, if they grow at all, produce yellow and sickly plants, which may rot off near the ground. The leaves are stunted and deformed, and the flower stalks decay and die or produce only distorted blossoms.

Control. The most important step in the control of BULB MITES is to cull out and burn all the soft and mushy bulbs. This should be done when the bulbs are being dug and again when they are being planted. Sound bulbs from an infested field may be cleaned fairly well by being placed for a few minutes in a nicotine solution made up with one ounce of 40% nicotine sulfate in three gallons of water. The bulbs should

¹⁴ *Rhizoglyphus hyacinthi* Boisd.

¹⁵ *Rhizoglyphus phylloxeræ* Riley.

not be held in this solution longer than 10 minutes, for they may be injured by it; and for the same reason no bulbs should be so treated after root growth has started. It is important, also, to have clean soil for bulb crops. If an infestation is not discovered until the bulbs have been planted and the crop is under way, or if control measures have not been effective, the only thing to do is to burn the plants and the soil in which they are growing.

Life History and Habits. BULB MITES lay their eggs behind the bud scales, each female producing from 50 to 100 eggs or more. The young nymphs, in the first stage of development after hatching, have six legs, but after moulting they have eight, and it is during this second stage of their life that they are most destructive. After moulting again, they become adults and live on for several weeks, feeding and producing eggs for the next generation. Mites in all stages may be found in one bulb at one time.

CACTUS PESTS

Mealybugs	p. 50
Scale Insects	p. 59

CALCEOLARIA PESTS

Aphids, or Plant Lice.....	p. 89
Cutworms	p. 36
Greenhouse Leaf Tyer.....	p. 39

Red Spiders (p. 75) are very difficult to control when calceolaria plants are badly infested with them. Careful syringing before the plants are in bloom, followed by a "Derrisol" spray when the plants are dry, will give considerable relief. Use one ounce of "Derrisol" in three gallons of water. Do not use oil emulsions on calceolaria

Thrips.....	p. 46
Whiteflies	p. 16

CALENDULA PESTS

Calendulas, which are rapidly coming into more general use as a greenhouse crop, are quite susceptible to insect attack. The major pests are the GREENHOUSE LEAF TYER and WHITE-FLIES. The other pests listed below sometimes attack calendulas. The numbers following the names refer to the pages where the pests are discussed under the crops on which they are more often found.

Cabbage Looper	p. 22
Cutworms	p. 36
Grasshoppers	p. 38
Mealybugs	p. 50

CALENDULA PESTS—*concluded**

Millipedes	p. 92
Sowbugs.....	p. 95
Tarnished Plant Bug.....	p. 43
Whiteflies	p. 16

CALLA PESTS

Red Spiders	p. 75
Thrips.....	p. 46

CAMELLIA PESTS

Scale Insects	p. 59
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CANDYTUFT PESTS

Aphids, or Plant Lice.....	p. 89
Cutworms	p. 36
Diamond-back Moth	p. 88
Slugs	p. 25
Tarnished Plant Bug.....	p. 43
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CARNATION PESTS

Of the major pests of carnations, the so-called RED SPIDERS are the most prevalent and destructive, and they are followed closely by the several species of THRIPS that attack this crop. The CABBAGE LOOPER, the GRASS MITE, SLUGS, and WIREWORMS are the other pests discussed here at some length as carnation insects, inasmuch as they may cause severe damage in years of abundance and are more likely to feed on carnations than other greenhouse crops. In addition, there are eleven other pests that sometimes attack carnations, and these are named in the following alphabetical series, each with a reference to the page where it is discussed under the crop on which it is more often found.

Since carnations are frequently grown outdoors during the summer months, great care should be taken not to transfer any pests to the greenhouse when the plants are brought in. All of the seventeen kinds of pests listed below may prove troublesome to the crop in the field and may be carried in with the plants in the fall. The control measures recommended are applicable under outdoor conditions unless otherwise stated in the discussion.

Aphids, or Plant Lice.....	p. 89
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CABBAGE LOOPER

The CABBAGE LOOPER¹⁶ frequently becomes a pest in greenhouses, particularly in the vicinity of fields of cabbage and related crops. The

¹⁶ *Autographa brassicae* Riley.

adults fly in through open doors and ventilators on warm nights in the fall of the year. The larvae are pale-green, striped caterpillars, up to $1\frac{1}{4}$ inches long, that crawl with a peculiar looping motion. Besides carnations, they attack calendulas, cinerarias, geraniums, chrysanthemums, and other crops.

Injury. The caterpillars feed both day and night, chewing holes in the leaves and eating off the young buds or boring into the more mature buds. Their method of feeding on the larger buds is similar to that of the CORN EAR WORM described on p. 35.

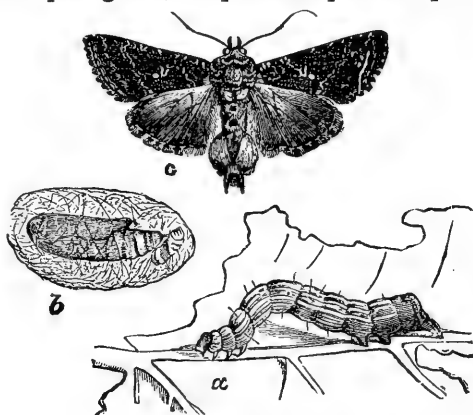


Fig. 5. Cabbage looper—(a) larve, (b) pupa, (c) adult. The larvae are heavy feeders, working on the under sides of the leaves and boring into the buds.

Control. When the larvae are numerous it is best to combat them by dusting the plants with a mixture of lead arsenate and lime, using one pound of lead arsenate to two pounds of hydrated lime. The plants should be lightly but thoroughly covered with the dust, since the caterpillars show a marked preference for feeding on any unpoisoned parts. *Warning:* Lime may injure some plants, and too much lime would make the soil too sweet for carnations. Hand-picking is recommended for a lighter infestation.

Life History and Habits. The adult of the CABBAGE LOOPER is a moth with a wing expanse of almost $1\frac{1}{2}$ inches. The fore wings, which are a very dark brown marked with lighter browns, have near the center a silvery spot shaped like an imperfect figure "8." The hind wings are grayish-brown, shading to bronze.

The female moth deposits her eggs, singly, on the under surface of the leaves of the host plant. The eggs, which are white, nearly round, and beautifully ridged, hatch in about 10 days in the greenhouse.

The mature caterpillar has two longitudinal stripes on each side and is noticeably larger at the posterior end, tapering to the head. Its peculiar looping method of crawling is similar to that of the so-called measuring worms. It becomes full-grown in two to four weeks and pupates in a light, loosely woven cocoon, from which the adult emerges in the following spring.

Corn Ear Worm	p. 35
Cutworms	p. 36

Eelworms (p. 90), which sometimes live over winter in the soil outdoors as far north as Cook County, may infest carnations in the field. Any plants showing eelworm injury should be burned. Those giving any evidence of even the slightest infestation should not be transferred to the greenhouse, and the soil in which they were grown should not be used for any greenhouse crop without sterilization (p. 91). Subsequent crops should be grown on new ground.

Grasshoppersp. 38

GRASS MITE

In the fall of the year, soon after carnations are benched from the field, rotting of the buds sometimes results from the work of the GRASS MITE.¹⁷ Although this mite normally is not a serious pest in Illinois, it is a potential pest of considerable importance to the grower, inasmuch as it may cause an epidemic of bud rot throughout the carnation house.

Injury. The buds fail to open or are deformed and later develop a characteristic rot, due to the growth of a fungus that is generally believed to be carried by the mites from plant to plant. The inner parts of a rotting bud will usually be found to contain many of the minute, water-colored mites and occasionally also one or more females with greatly enlarged abdomens.

Control. The mites gain entrance to the greenhouse in soil or on plants brought from the field. New soil taken from a field under clean cultivation, or from a field with a good stand of clover or alfalfa free from grass and weeds, will be practically free of mites. Plants growing in the field should be kept under clean cultivation and free from grass and weeds. Whether or not this is done, the plants should be given a thorough examination before they are benched. A barren strip around the field will also act as a preventive measure.

Once the mite has gained entrance to the greenhouse, the only recourse is to pick and destroy the infested buds as soon as they are observed. The walks and the ground under the benches should be sprayed weekly with 5% kerosene emulsion (p. 109). Take care to keep the spray from hitting the plants, as it will severely injure them.

Life History and Habits. The adults have a typical mite structure with shiny bodies. The females retain the young in the abdominal sac until development is completed. Each female is capable of giving birth to about 200 young, some of which may crawl to other buds and thus spread the disease.

¹⁷ *Pediculopsis graminum* Reuter.

Greenhouse Leaf Tyer.....	p. 39
Millipedes	p. 92

Red Spiders (p. 75) can be controlled on carnations by spraying the plants thoroughly with lime-sulfur. On well-established plants before blooming starts, use one ounce of dry lime-sulfur in one or two gallons of water. Tender varieties and plants that are putting out new growth rapidly should be sprayed at a weaker dilution, one ounce in three gallons of water. All plants should be thoroughly and forcibly syringed from all sides with clear water within two days following the lime-sulfur applications. The spraying and syringing should be repeated every ten days until the pests are under control, and then the syringing alone will suffice to hold them in check. *Caution.* It is advisable to go slow in using any oil sprays on carnations, since the "bloom" on the plant may be injured. Never use oil sprays on carnations or any other plants if the leaves show a residue of sulfur from previous treatments.

SLUGS

Leaves of carnations and other plants in greenhouses are often eaten into during the night by SLUGS which leave a tell-tale, shiny trail wherever they have crawled. These pests prefer damp places and will be found under pots and boards or in the cracks and crevices in the bench.

Injury. SLUGS usually eat out sections along the edges of the leaves or make holes through the leaves. Young slugs may skeletonize the leaves, causing an injury which may be mistaken for that caused by LEAF TYERS, but their work can always be distinguished by their trails of dried slime. SLUGS also attack seedlings and growing plants of orchid, snapdragon, coleus, chrysanthemum, cineraria, and other crops in the greenhouse.

Control. Plants that will not be in bloom for several weeks may be protected against SLUGS by means of a lead arsenate spray. Use one ounce of fish-oil soap or laundry soap and one ounce of lead arsenate in two gallons of water. Later, when the plants are in bloom, hydrated lime or finely ground tobacco dust distributed liberally in the places frequented by the slugs will give relief within a short time. The tobacco dust is the better material to apply on the bench surface. The hydrated lime should be dusted under the benches and along the edges of the benches and the walks. The dust should be renewed after syringing and watering, and to be most effective it should be kept as dry as possible. The poison bran bait described on p. 107 is also effective.

Life History and Habits. SLUGS are shiny, slow-moving, repulsive creatures, often incorrectly called snails. They differ from snails in not having shells. They range in length from $\frac{1}{2}$ inch to nearly four inches and are colored bluish-black, gray, brown, or mottled. The species¹⁸ of SLUG most destructive in Illinois greenhouses is black or bluish-black. The head is provided with cutting mouth parts and two tentacles, and eyes on stalks.

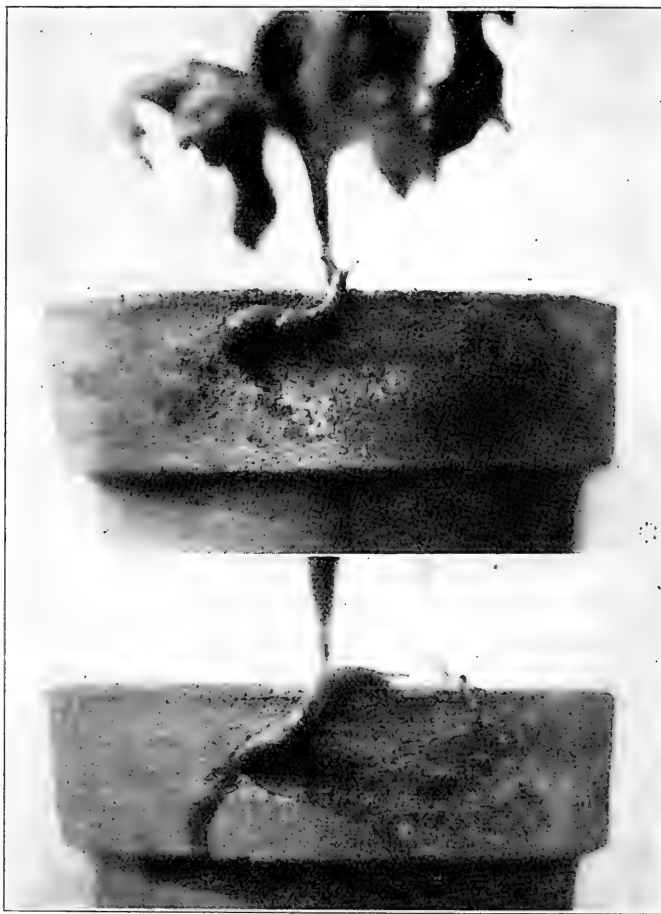


Fig. 6. Slug. This bluish-black slug attacks a wide range of crops.

SLUGS are hermaphroditic. The eggs, which are laid in masses in damp places, are held together by a yellow secretion. They hatch in about a month. The young resemble the adults but are very small and develop very slowly, requiring several months to attain their full growth.

Sowbugs.....p. 95

Termites.....p. 44

¹⁸ *Agriolimax campestris* Say.

Thrips (p. 46) cause a very pronounced injury on carnations and are likely to be most troublesome during the fall and early winter months. The sunken, white areas on the leaves where they feed are particularly noticeable on carnation foliage. The adults are most numerous in the axils of the leaves, and the young imbed themselves among the petals of the flower buds, where they are protected. Their feeding on the petals and on the undeveloped buds results in streaked, crippled, and softened flowers. A light infestation is sufficient to cause severe injury to young cuttings. For these reasons it is very important to keep **THRIPS** under control at all times. The control measures recommended on p. 47 are applicable in the carnation house. The home-made nicotine dust will be found to be very effective.

WIREWORMS

WIREWORMS¹⁹ are round, hard, smooth, reddish-brown, worm-like larvae, up to 1½ inches long, which should be looked for in the soil at the base of stunted or wilted plants. While they are not a frequent greenhouse pest, they may be brought in when a change of soil is made or when stock plants are transferred from the field. They are usually most destructive in the carnation house, but they also attack many other crops.

Injury. **WIREWORMS** chew off the roots of plants and seedlings, often boring into the fleshy stems of carnations near the base and causing the plants to turn yellow and wilt.

Control. If infested soil must be used in filling the benches, it should be sterilized with steam (p. 91) or treated with carbon bisulfide (p. 106). Pieces of potato buried in the soil will trap many **WIREWORMS** and should be taken up, and the worms destroyed, at intervals of a few days, preferably before a crop is planted.

Outdoors, more can be accomplished in the control of **WIREWORMS** by employing suitable cultural methods than in any other way. **WIREWORM** injury in the field is more likely to occur when new land is broken. Where the carnation field is to be rotated with a grass or clover crop, a short rotation is desirable. Early fall plowing, followed by harrowing once a week for a month, will destroy large numbers of pupae and newly formed adults. Since most cases of **WIREWORM** injury are associated with poor drainage, and since good drainage is essential to success in growing carnations, growers should check up on the drainage in fields where **WIREWORMS** are a continual nuisance.

¹⁹ Several species belonging to the family *Elateridae*.

Cyanide treatment of fields has proved very effective in the West. Old beans are seeded with a drill, and a week or 10 days later the calcium cyanide in granular form is put into the soil by means of the same kind of a drill but a little deeper.

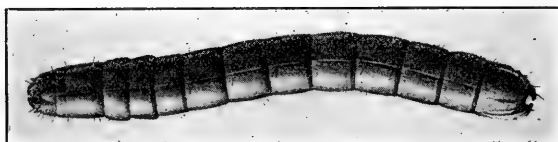


Fig. 7. Wireworm larva. The larvae chew off small roots and burrow into the underground stems of many crops.

Life History and Habits. The adult form of the WIREWORM is the familiar CLICK BEETLE which, when placed on its back, will jump into the air with a "click" as it strives to gain footing. The female lays the eggs in the soil, preferring sod land. The larvae are elongated, shiny, wire-like grubs with distinctly segmented bodies. They live in the soil from two to six years, feeding almost continually throughout each growing season, and increase gradually in size until they become about 1½ inches long. Then they pass into the pupal stage for one winter and emerge as adult beetles the following spring.

CHERRY PESTS

Eelworms	p. 90
Red Spiders	p. 75

CHRYSANTHEMUM PESTS

Among the major crops grown under glass in Illinois, the chrysanthemum crop is susceptible to serious damage by the largest number of pests. The writer has observed more than two dozen kinds of pests in chrysanthemum houses in this state. Ten of these are discussed here because they usually do more damage to 'mums than to other crops. The most important one is the GREENHOUSE LEAF TYER, for it is by far the most widely distributed and, over a period of years, the most destructive of them all. The second in importance is the CHRYSANTHEMUM MIDGE, which is capable of doing more damage than the leaf tyer in an individual house, but which can be excluded and eradicated. The other major chrysanthemum pests are THRIPS, APHIDS, CUTWORMS, GRASSHOPPERS, the CORN EAR WORM, the CHRYSANTHEMUM LEAF MINER, the BURDOCK LEAF MINER, and the TARNISHED PLANT BUG. In addition, a dozen other pests that sometimes attack 'mums in greenhouses, are listed alphabetically in the following series, with cross-references to the discussions of their

work on the crops which they usually damage most. The control measures recommended for use against these latter pests on their respective crops are applicable also to chrysanthemums, unless otherwise specified.

Ants, see Root Aphids and Ants.....p. 94

APHIDS, OR PLANT LICE

APHIDS, or PLANT LICE, are more often known to the chrysanthemum grower as "GREENFLIES" or "BLACKFLIES," names which describe these insects very well, although APHIDS are not FLIES in the precise sense of the word. All APHIDS are true sucking insects that insert their beaks through the surface of the leaf or stem and extract the juices from within. The "BLACKFLIES" usually congregate on the terminal shoot and new growth, while the "GREENFLIES" may attack the leaves as well. When but a few "GREENFLIES" are present, they will be found on the edge of a leaf, feeding in the notches, where they are difficult to see.

Injury. The feeding of APHIDS causes chrysanthemums and other plants to become sickly and stunted. The leaves curl inward, and when the flower terminal is infested the blooms will be deformed. Certain varieties of chrysanthemums are more susceptible to attack than others. The variety Celebration is an example of extreme susceptibility.

Control. Fumigation is the preferred method of control when a considerable number of plants in a chrysanthemum house are found to be harboring APHIDS. Where mixed crops are grown, it is often more expedient to dust or spray the infested plants, in order to keep down the expense. Whatever spray or dust is used, it must hit the body of the insect in order to be effective.

Fumigation with cyanide or nicotine (see pages 102-106) is effective against APHIDS. The materials sold under trade names should be used at the rates suggested by the manufacturers until tests in the individual house have shown the proper amount to use.

An effective spray may be made up with 40% nicotine sulfate, used at the rate of one fluid ounce to five or six gallons of water. Add one ounce of fish-oil soap or laundry soap for each gallon of spray, except on tender foliage that may be burned by soap.

Nicotine dust (p. 107), containing 2.4% actual nicotine, is effective against all species of APHIDS.

"Derrisol" and "Evergreen," comparatively new commercial compounds, are also effective. They should be used as directed on the containers.

Special care must be used in applying any control measure against the "BLACKFLIES," as they are more resistant than the "GREENFLIES" to all insecticides and fumigants.

Out of doors APHIDS have many natural enemies which aid the greenhouse man by reducing the sources of infestation. (See *Beneficial Insects*, p. 11.) In the greenhouse, however, the natural enemies are not often of great importance in control. At the present time it is more expedient to apply control measures against the insects than to foster the development of parasites.



Fig. 8. Aphids, or "greenflies," on chrysanthemums.

Life History and Habits. There are many species of "GREENFLIES" that attack greenhouse crops. One of these, the GREEN CHRYSANTHEMUM APHID,²⁰ is said to feed only on chrysanthemums. There is but one species of "BLACKFLY" found on chrysanthemums, the BLACK CHRYSANTHEMUM APHID,²¹ and it also feeds on no other crop, so far as known. It is easily distinguished by its color and by the relatively large size of its abdomen. Chrysanthemums are attacked also by several species of GREEN APHIDS which are difficult to identify, but the control measures and life histories are practically the same for all of them.

Almost all APHIDS found in the greenhouse are females, for the males do not normally occur indoors. Each mother aphid, when about a week old, begins to give birth to living young and may produce 50 or more within a few days. Since

²⁰ *Colorodoa rufomaculata* (Wilson).

²¹ *Macrosiphoniella sanborni* (Gillette).

all the young are females, which in time give birth to more females—fifty or more, again—the rate of multiplication is very high. This process goes on indefinitely, without any egg stage or pupa stage. The young, born alive and nourished by the juices of the plant, simply grow to maturity and reproduce. **APHIDS** breed in the greenhouse throughout the year.



Fig. 9. Black chrysanthemum aphid. One of our most difficult species to control.

BURDOCK LEAF MINER

The **BURDOCK LEAF MINER**²² is similar to the larvae of the **MARGUERITE FLY** (p. 32) and works in much the same way on chrysanthemums and on a few other plants. It may, however, make larger brown blotches, often covering the whole leaf. Two or three maggots, instead of only one, may feed in the same burrow. The injury may appear somewhat like that caused by the **GREENHOUSE LEAF TYER**, except that the leaf surfaces are not destroyed and there is no tying together of leaves. The **BURDOCK LEAF MINER** is likely to be most troublesome from August until November, but it can be controlled by the same methods as are recommended for the **MARGUERITE FLY**.

²² *Agromyza maculosa* Malloch.

Life History and Habits. The adult of the BURDOCK LEAF MINER is slightly larger and much darker than the MARGUERITE FLY, being $\frac{1}{8}$ inch in length and shiny black in color. Its body is rather stubby instead of sharply pointed. Within six or eight days after the female lays the eggs in the leaves, the tiny white maggots hatch out and immediately start feeding in more or less circular areas. Their growth is completed in two to three weeks, and then they pupate in their burrows, emerging as adults about two weeks later.

Centipedes, *see* Symphylids.....p. 96

CHRYSANTHEMUM LEAF MINER, OR MARGUERITE FLY

The larva, or maggot, of the MARGUERITE FLY²³ disfigures and weakens chrysanthemum plants by mining in the leaves, and for this reason it is known as the CHRYSANTHEMUM LEAF MINER. It may do considerable harm to the crop, but it is easily held in check, though not so easily eradicated from the house, by the prompt use of control measures.

Injury. The young maggots burrow in the leaf tissue, leaving the upper and lower surfaces intact. The tunnels are irregular and winding, and are constantly extended and widened as the maggots grow. White blotches are thus formed, which later turn brown, and the leaves may die. The injury may be mistaken for that of the BURDOCK LEAF MINER (p. 31), which is a closely related pest.

Control. As soon as it is noticed that any leaves are infested, they should be picked off and burned, if the infestation is not already so widespread as to make hand-picking impracticable. Fumigation with nicotine or cyanide, at the strength usually used in chrysanthemum houses, will kill the adult flies but has no effect upon the eggs, larvae, or pupae in the leaf. Infested plants, therefore, should be sprayed thoroughly, at intervals of a week or ten days. Use one fluid ounce of 40% nicotine sulfate and three ounces of laundry soap in three gallons of water. This spray will kill most of the maggots before they have time to do much damage.

Life History and Habits. The adult of the CHRYSANTHEMUM LEAF MINER, OR MARGUERITE FLY, is about $\frac{1}{12}$ inch in length and has a short-pointed, grayish body. The female drills very small holes into the leaf and lays her eggs there, one in each hole. The footless, yellowish maggots hatch from the eggs in about a week and begin at once to make their tunnels through the leaf. They complete their growth in about two weeks, becoming almost $\frac{1}{8}$ inch long, and pass another two weeks resting as pupae in their burrows in the leaves before emerging as adult flies. They are likely to be most troublesome during the fall months.

²³ *Napomyza chrysanthemi* Kowarz.

CHRYSANTHEMUM MIDGE

Small, hard, blister-like galls on the leaves of chrysanthemums, or conical galls protruding obliquely from the surface of the leaves and stems, indicate an infestation of the CHRYSANTHEMUM MIDGE.²⁴

Injury. Chrysanthemum plants attacked by the MIDGE may become sickly and often have deformed leaves and blooms on crooked stems.



Fig. 10. Leaf injury by the chrysanthemum midge. The orange-colored maggots will be found within the galls on the leaves and stems.

The galls, which are caused by the feeding of the larvae, are found normally on the upper surface of the leaf, but sometimes occur on the under surface also. Even when so small as to be hard to see, the galls may be easily discovered by drawing the leaf between the thumb and forefinger. There may be a score or more of them on a single leaf or cutting. The midge is most troublesome during the spring and fall months.

²⁴ *Diarthronomyia hypogaea* Loew.

Control. Since the CHRYSANTHEMUM MIDGE rarely gains entrance to the greenhouse by means of its own powers of locomotion but is usually carried in on infested stock plants and cuttings, the utmost care should be exercised in buying and inspecting all new plants. Infested cuttings should be returned to the seller at once. The grower will do well to become thoroughly familiar with the appearance of the galls and with the life history and habits of the MIDGE, as this knowledge will aid greatly in controlling the pest.

Control operations should begin early in the season, preferably in February. The galls may be looked for, first, on the varieties having the lighter-green foliage, inasmuch as these are most attractive to the MIDGE. Lightly infested plants should be inspected frequently, and all leaves having galls should be removed and burned. For further protection, the plants should be sprayed every second day. Use one fluid ounce of 40% nicotine sulfate and six ounces of laundry soap in six gallons of water, and apply the spray after 4 p. m. When the leaves and stems are badly infested, it will be found expedient to fumigate with nicotine or cyanide every night for a period of four to six weeks, or at least for a week after all traces of the MIDGE have disappeared. One-half the usual dosage of nicotine or cyanide (see p. 103) is sufficient for this work, and it should be used about midnight to insure the best results. In addition to fumigating, it will be found beneficial to keep the plants covered with a tobacco dust containing not less than 1% nicotine.

The rather general recommendation of pulling up and destroying heavily infested plants, if followed, often results in the loss of valuable stock that may be difficult to replace. A less drastic practice, recommended by Mr. H. F. Dietz, consists in cutting the tops close to the ground and removing and burning them. When done early enough, this has been found practical and effective under very severe conditions. The new growth will come strong and clean.

There is little that can be done when unrooted cuttings have become infested. They should be turned before the flies have emerged. Rooted cuttings that have been potted up or transferred to the benches may be sprayed or fumigated, or both, as directed above.

When the main crop is infested, nightly fumigation should be resorted to as the only efficient means of control.

Life History and Habits. The adult of the CHRYSANTHEMUM MIDGE is a very small fly, about 1/14 inch in length, resembling a miniature mosquito in general appearance, except that its body is yellowish to reddish-orange. It has two delicate transparent wings.

The adults are rarely seen in the greenhouse, and the maggots can be seen only by opening the galls. Identification is best made by the character of injury.

The flies emerge from the galls between the hours of midnight and 3 a. m. Mating then takes place, and egg laying begins within a few hours. By 8 or 9 o'clock in the morning, the flies that emerged during the night have finished laying their eggs and have begun to die.

Each female lays 100 eggs or more, in rows on the tender shoots and new growth. Often the new growth is literally brick-red at or near the tip. If one closely examines this mass, he will see dozens of minute, reddish-orange eggs, four or five times as long as they are broad. The eggs hatch in 3 to 14 days, depending largely on the temperature.

Each maggot, upon leaving the shell, crawls over the surface of the leaf, often for two or three days, before entering it. The gall, in which the maggot will mature and pupate, begins to form a few days later, and increases in size for a week or two; then it turns brown at the tip, a day or two before the fly emerges.

Four to six weeks are thus required to complete the life cycle. Although the broods are sometimes rather well defined, all stages are often present at the same time.

CORN EAR WORM

The CORN EAR WORM²⁵ is a green-to-brown, nearly smooth caterpillar, often mistaken for a CUTWORM when found within the buds or on the opening flowers of chrysanthemums, carnations, and roses. It feeds to a lesser extent on the leaves of these latter plants and also of sweet peas, geraniums, and other crops.

Injury. In the greenhouse this caterpillar seldom attacks any part of the chrysanthemum plant except the bud or flower. It is very destructive to the opening buds, for it feeds on their petals and other parts, deforming if not entirely ruining the flowers. Often it works its way so far into the bud that only a little of its body can be seen sticking out. It is likely to be most troublesome during the months of August, September, and October.

Control. If the attacked plants are blooming, spraying is out of the question, but thorough treatment with sulfur-lead dust as recommended for the GREENHOUSE LEAF TYER (p. 39) will also hold CORN EAR WORMS in check. After they have worked their way into the buds and are found to be feeding on the open flowers, hand-picking is the only remedy. This is best done after dark, with the aid of a lantern or flashlight, since the caterpillars are most active at night. Any of the adults seen in the greenhouse should be killed.

²⁵ *Heliothis obsoleta* Fab.

Life History and Habits. The adult of the CORN EAR WORM is a moth with a wing expanse of $1\frac{3}{4}$ inches. The fore wings are straw-colored, more or less variegated, and marked with a dark area in the center and another near the tip. The hind wings are cream-colored, with a dark-shaded area along the hind margin and two lighter spots near the edge.

The CORN EAR WORM does not survive the winter in northern Illinois, but the moth migrates from the south each year. The first brood is not usually troublesome in the greenhouse. The moths of the second brood, however, fly in through the ventilators to lay their eggs on the leaves and buds of the plants. The eggs are very small, white, and nearly round, with a flattened base.

The mature larvae have an almost smooth body, about $1\frac{1}{2}$ inches in length, marked with characteristic longitudinal stripes. The younger specimens, which

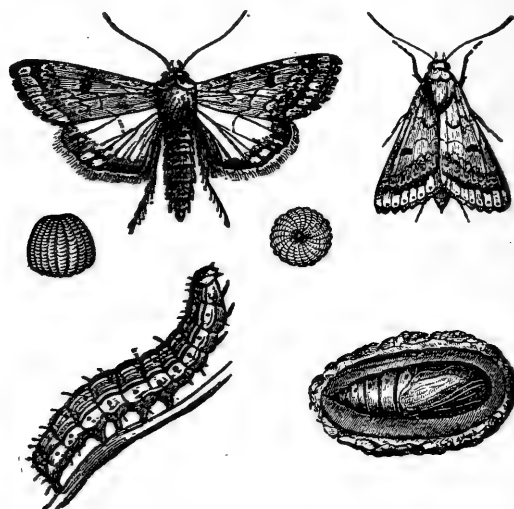


Fig. 11. Corn ear worm—adult, eggs, larva, and pupa. The larvae bore into the buds of carnations, chrysanthemums, and roses.

are more often seen in the greenhouse, appear more hairy. The color varies from green to brown. When full grown, or about four weeks old, the larvae burrow into the ground in much the same manner as CUTWORMS. There they transform into smooth, brown pupae nearly an inch in length, from which the moths later emerge.

Cockroachesp. 73

CUTWORMS

CUTWORMS²⁶ generally are recognized at sight for what they are—dangerous caterpillars with a preference for tender plants and a weakness for poison bait. Their sleek, sparsely-haired, dull-colored bodies,

²⁶ Various species of the family *Noctuidae*.

from one to more than two inches in length, always have the appearance of being well fed. They are most active at night, and usually spend the day coiled up just under the surface of the soil at the base of the plant, though they sometimes may be found during the day stretched out along the midrib of a leaf. They should not be confused with the CORN EAR WORM (p. 35) which cannot be controlled by poison baits. While the following description applies particularly to CUTWORMS on chrysanthemums, the control measures recommended below are applicable also to other crops.

Injury. CUTWORMS obtain their food by biting out sections of the leaf, stem, or bud. Some species when very young, may eat small circular holes in the leaves, but later they usually eat from the edge of the leaf, devouring part or all of it as they go. Other species attack the stem of the growing plant at the surface of the ground, or just above or below the surface, either cutting off the stem completely or weakening it so that the plant withers. Still others climb to the top of the stem and eat into the flower buds.

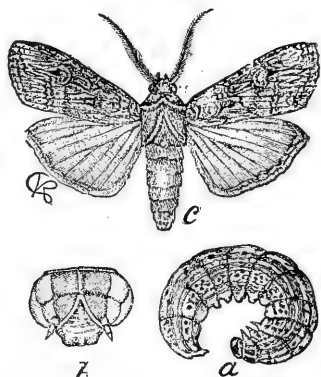


Fig. 12. Adult and larva of the variegated cutworm.

Control. CUTWORMS are most likely to be brought into the greenhouse as partly grown larvae when a change of soil is made. Therefore, the best time to take precautions against them is immediately after the new soil has been placed in the bench, for then they can find little else to eat and will readily feed on poison baits. (Directions for preparing bran bait are given on p. 107.)

Any bait used for CUTWORMS should be distributed very thinly over the bench several consecutive nights before and after a crop is planted. The bran bait should be moist enough to form a loose ball when squeezed in the hand. All baits should be distributed after sunset, since they will be less palatable to the cutworms if allowed to dry out.

After the CUTWORMS have started to work on the crop, they are not so easily lured to the bait. Those that feed on the foliage may be killed by spraying the plants with arsenate of lead, if the discoloration of the foliage is not objectionable. From two-thirds to one ounce of the arsenate should be used to each gallon of spray.

Those species that feed entirely underground are difficult to poison, especially after a crop has been planted, and then it may be necessary to dig them up where they are hiding close to the injured plants and near the surface.

Life History and Habits. CUTWORM adults are dull-colored, heavy-bodied moths. They are rarely seen in the daytime but fly about at night, when they are often attracted to lights. Most of them have dark-brown fore wings, streaked or mottled with various shades of yellow, gray, brown, or black. The hind wings are lighter in color and not so distinctly marked.

These moths usually lay their eggs outdoors, on garden plants, grasses, or weeds, but they occasionally fly into the greenhouse and lay the eggs on chrysanthemums and other plants. The moth of the VARIEGATED CUTWORM²⁷ is the most frequent invader of greenhouses in Illinois.

The young cutworms, for a few days after they hatch from the eggs, are usually darker and more hairy than the mature ones. All species feed on a wide variety of plants and become full-grown in about a month. Then they change into pupae—naked, shuttle-shaped, dark-brown bodies, about one inch in length—and are usually found in the soil where they have constructed small earthen cells. They remain in this resting stage for about two weeks before they become moths, ready to lay eggs to start a new generation.

Cyclamen Mite (p. 52) sometimes becomes a serious pest of chrysanthemums. The injury is often mistaken for red spider injury. In cloudy weather the mites may be controlled by a spray. Use 40% nicotine sulfate at the rate of one ounce in four gallons of water, and add one ounce of laundry soap or potassium fish-oil soap for each gallon. If the weather is fair, syringe twice a week with clear water.

Garden Centipede, *see* Symphylids.....p.96

GRASSHOPPERS

In the fall of the year, when GRASSHOPPERS are abundant and when food for them outdoors is becoming scarce, they frequently fly into the greenhouse through open doors and ventilators to feed on chrysanthemums and other plants. They are most destructive when the chrysanthemums are coming into bloom. The RED-LEGGED GRASSHOPPER²⁸ is the chief offender among the several species found in Illinois.

Injury. These ravenous insects, if numerous enough, could devour the entire crop, chewing up the leaves and other parts of the plants until nothing would be left but the tougher stems. Although only a few usually come into the chrysanthemum house, they often do serious damage, for they seem to have a preference for the opening buds, and a single GRASSHOPPER is capable of destroying the commercial value of half a dozen blossoms within a short time.

²⁷ *Lycophotia saucia margaritica* Haw.

²⁸ *Melanoplus femur-rubrum* DeG.

Control. Screens over the doors and ventilators and a clean-culture strip around the house will reduce the danger of an invasion.

Before the buds begin to open, GRASSHOPPERS may be killed by spraying the plants with arsenate of lead, using two-thirds ounce to one gallon of water, or by dusting with sulfur-lead as directed on p. 40.

The poison bait described on p. 107 will be found of value in reducing their numbers. It should be broadcast for a short distance outside the greenhouse as well as inside.



Fig. 13. Grasshopper.

When the chrysanthemum crop is about ready to cut, it is often expedient to pick off the GRASSHOPPERS by hand. This can be done best at night, using a lantern or flashlight.

Life History and Habits. GRASSHOPPERS do not normally breed in the greenhouse but outdoors. The eggs are laid in the ground. The young resemble the adults in shape and color but are smaller and have no wings. They feed in all stages of their development.

GREENHOUSE LEAF TYER

The GREENHOUSE LEAF TYER²⁹ is a pale-green, lightly striped caterpillar that does serious damage to chrysanthemums and many other soft-leaved plants by eating away the under surfaces of the leaves. It gets its name from its habit of spinning light webs inclosing two or more leaves or tying together the parts of a single leaf. This caterpillar is very active and, when disturbed, will wriggle off the leaf, often backward, lowering itself on a silk-like strand. It is most troublesome in the greenhouse from March to July and from September to December.

Injury. When first hatched, the larvae eat out shallow holes on the under side of the leaves. As they grow, they enlarge these holes but usually do not cut through to the upper surface. The result is that the leaves become skeletonized. Chrysanthemums attacked in this way may be so disfigured as to be unfit for sale.

On roses, cinerarias, lupines, calendulas, snapdragons, marguerites, and similar plants, the injury is like that on chrysanthemums. On violets, the larvae eat small circular holes through the leaves in addition to skeletonizing them. Other greenhouse crops sometimes attacked are sweet pea, geranium, ageratum, carnation, petunia, begonia, cyclamen, lantana, aster, coleus, and primrose.

Control. It is advisable to combat the adult moths of the GREENHOUSE LEAF TYER as well as the larvae themselves. The best method

²⁹ *Phlyctaenia ferrugalis* Hb.

now known for killing the moths consists in the use of light traps. Clear-glass 200-watt lamps are hung above the benches at intervals of 75 feet or less, and a shallow pan containing a little kerosene and water is suspended five or six inches below each lamp. In order to arouse the moths so that they will be attracted to the lights, it is desirable to tap the stems of the plants gently with a short piece of rubber hose, or to use a light fumigation with nicotine. The lamps should be turned on within an hour after sundown, and it will not pay to run them longer than three hours. Tests of red, white, blue, and green lights have shown conclusively that the white lights are most attractive.

For combating the larvae, the best poison is arsenate of lead, either in the form of a dust or a spray. The dust has certain advantages over the spray, in that it is more easily and quickly applied, does not discolor the foliage for any length of time, and filters through the webs and onto the leaves where the insects are feeding. Sulfur-lead dust for this purpose may be purchased from dealers in insecticides, or it may be made easily and cheaply as follows:

Dusting sulfur (300 mesh)....	85 parts by weight
Arsenate of lead.....	15 parts by weight

The ingredients should be weighed, not measured by volume. They should be thoroughly mixed by running through a fine screen three or four times and stirring before each screening.

The dust or spray should be directed to the under sides of the leaves. Particular care should be taken to cover the leaves on the lower third of tall-growing plants, for it is here that the majority of the eggs are laid and the young caterpillars begin their work.

In the narrow greenhouse walk, the dust is best applied with a duster of the puff type. Applications of dust should be made after each syringing—as soon as the plants have dried. Weekly applications are often necessary during the outdoor growing season and as long as the ventilators are open during the evening. Bi-weekly applications are usually sufficient during the winter months.

A spray, which will remain effective somewhat longer than a dust, may be used to advantage on potted plants or on plants that will not be ready for sale for several weeks. Use one ounce of arsenate of lead in one gallon of water to which has been added $\frac{1}{2}$ ounce of fish-oil soap or laundry soap. Potted plants with dense foliage may be dipped in the above solution to insure a thorough covering.

LEAF TYERS infesting seedlings and flowering plants, such as cinerarias, begonias, geraniums, and others, which are to be sold within

a short time, may be picked off by hand, or the plants may be protected with a pyrethrum spray that will not discolor the foliage.

Life History and Habits. The adult, or moth, of the GREENHOUSE LEAF TYER is less than $\frac{1}{2}$ inch long and has a wing expanse of about $\frac{3}{4}$ inch. During the day, it is likely to be seen resting under the leaves or sometimes on the glass side-walls and frame-work of the greenhouse. When at rest, its wings are folded along its back, so that it has a triangular appearance. Its general color is pale brown or dark-tan above and buff below. The fore wings are marked with transverse, wavy, dark-brown lines. There are numerous small dark spots on the under side of the wings and body. The moths usually remain in hiding during the day, though they occasionally fly and even lay eggs on dark, cloudy days. At dusk they become active and move about the greenhouse in short choppy flights, laying their eggs on the leaves of the plants.



Fig. 14. Greenhouse leaf tyer—adult, larva, and pupae. Showing the small pit-like holes eaten out of the chrysanthemum leaf by the young larvae. One pupa is shown within the folded leaf lobe.

The eggs are laid singly or in small clusters, usually from 2 to 5 but occasionally as many as 15 being found in a single cluster, where they overlap. They are very small, nearly round, flattened, and almost transparent. If 32 of them were placed side by side in a row, they would measure an inch. In the chrysanthemum house the eggs hatch in 4 to 18 days, with an average incubation period of 11

days in winter and 7 days in summer. Just before an egg is ready to hatch, the dark head of the young larva within the shell can be readily seen without the aid of a magnifying glass.

The newly hatched larva is very slender and about 1/25 inch in length. During its growth, which requires from three to four weeks in the chrysanthemum house, it sheds its skin five times. The head and the body are sparsely covered with stiff hairs. When fully grown, it is about 3/4 inch in length and is plainly marked with longitudinal stripes of darker or lighter green. It now makes ready for the transformation to its pupal stage, by bringing two or more leaves together and tying them with silk-like threads; or it may cut the edge of a leaf and fold over the resulting flap, so as to form a place of protection within; or it may crawl away from the plant to seek trash on the bench or some crevice in which to hide. About a third of the larvae leave the host plant for pupation. An average of 10 days is spent in this resting stage; then the adult moths emerge, usually at night, and by the following night the females are ready to lay eggs.

In the greenhouse there are seven or eight generations a year, five to eight weeks being required for each one. Since the generations overlap, all stages may be present at the same time and often on the same plant. Outdoors the LEAF TYERS breed freely during the summer months on weeds and on some cultivated crops. At the approach of cold weather in the fall, the moths seek shelter in the greenhouse, gaining entrance through doors and ventilators or being carried in on infested stock grown outdoors.

Grubworms, see White Grubs.....p. 83

**Leaf Miners, see Burdock Leaf Miner, p. 31, and
Chrysanthemum Leaf Miner.....p. 32**

Mealybugs (p. 50) may spread to chrysanthemums from coleus or other foliage plants grown in the same house, and may weaken the terminal buds so as to cause the flowers to be soft. Syringing with clear water will remove the MEALYBUGS before the flowers begin to open. A new species of MEALYBUG, *Phenacoccus gossypii*, now established in Illinois is exceedingly destructive to chrysanthemums. If these pests are not brought under control by syringing before the buds are formed, they are most difficult to hold in check.

Midges, see Chrysanthemum Midge.....p. 33

Millipedesp. 92

Mites, see Cyclamen Mite.....p. 38

Red Spidersp. 75

Root Aphids and Ants.....p. 94

Slugsp. 25

Sowbugs.....p. 95

Symphylidsp. 96

TARNISHED PLANT BUG

The TARNISHED PLANT BUG,³⁰ or "STING FLY," a pest with a long record of mischief in gardens and orchards, comes into the greenhouse through open doors and ventilators in late summer or early fall and does considerable harm to many crops, especially chrysanthemums. It is only $\frac{1}{4}$ inch long, brassy-brown, and mottled with various reddish and yellowish shades which give it a "tarnished" appearance. Being small and inconspicuous, this bug is often overlooked by the grower, who may therefore not take the necessary precautions to prevent the harm it may do.

Injury. Like other sucking insects, this pest robs plants of some of their juices. It also causes an indirect and more important kind of injury that may baffle the greenhouse operator. Wherever it inserts its beak, a diseased condition may develop as an after-effect. Leaves so punctured become spotted, and buds either die or fail to open normally. Since these bugs are very active, moving from plant to plant, a few of them may in a short time produce an apparent epidemic of disease throughout the house. Besides chrysanthemums, they feed on asters, marigolds, and numerous other crops in the greenhouse, and on almost every kind of vegetation outdoors.



Fig. 15. Adult of the tarnished plant bug, greatly enlarged. Often called the "sting-fly" of chrysanthemums.

Control. Screening the doors and ventilators, if practicable, will serve to keep out the TARNISHED PLANT BUG as well as many other insects. The customary fumigating and spraying practices generally prevent its breeding within the greenhouse. Sanitation, however, is the best precaution against this insect. If the operator will take the trouble to remove all dry and loose rubbish and trash that may be on, around, or under the benches, the bugs will have few hiding and breeding places and can be more easily detected and destroyed. Since weeds and rubbish outside the greenhouse also afford ideal places for the bugs

³⁰ *Lygus pratensis* (L.).

to feed and breed, clean culture for a distance of twenty to fifty feet entirely around the greenhouse will aid greatly in reducing the danger of an invasion.

If discovered on the plants, the bugs can be quite easily picked by hand during the early morning hours, since they are sluggish at that time. A pyrethrum spray (p. 108) will kill most of the young and some of the adults—as many as are hit with the spray. Spraying, however, is not very satisfactory at best, because of the difficulty of hitting the active adults.

Life History and Habits. The female lays her eggs in a wide range of cultivated crops and weeds, inserting them in the leaf veins and stems. Each egg hatches into a nymph that somewhat resembles the adult but has no wings. The young nymph is about 1/25 inch long, with an oval body and long legs. At first it is colored in various shades of green and has four black spots on the back, but as it grows it moults five times and becomes mottled with brown. There are about four generations in a season, and the number of the bugs increases greatly toward fall. Both old and young have an indiscriminating and almost insatiable appetite for plant juices.

TERMITES

TERMITES,³¹ sometimes called WHITE ANTS, are wood-eating insects that occasionally attack chrysanthemums, asters, geraniums, and other woody-stemmed plants. Their injury to crops, however, is very slight in comparison with the extensive damage they do to greenhouses and other buildings constructed wholly or partly of wood. Foundations, walls, benches, and roof supports, if of wooden structure, are susceptible to attack by these pests, which always work under cover and often give no easily noticeable evidence of their presence until part of the structure is so weakened by them that it begins to give way. There is little chance of such damage to greenhouses of the type now being built, but the older wooden houses will bear frequent inspection.



Fig. 16. Termite worker.

Injury. The first indication that TERMITES, or WHITE ANTS, may be tunneling in the woody stems of plants is a yellowing and wilting of the leaves. If an infested plant is pulled up, the stem will be found to be hollow where the pests have eaten out the core, and their point

³¹ *Reticulitermes flavipes* (Kollar).

of entrance may be discovered on the side of the stem just below the surface of the ground. The roots are never attacked, nor the outside of the stem.

Infested posts, walls, and benches may appear sound enough and still be riddled inside by *TERMITES*, for these pests work only in the dark and always leave intact at least the outer shell of the wooden structure, so that their presence is usually not suspected until the structure becomes weak and gives way. There is most danger of infestation wherever the wood comes in direct contact with the soil. Even where there is no such contact the *TERMITES* may reach the wood by tunneling

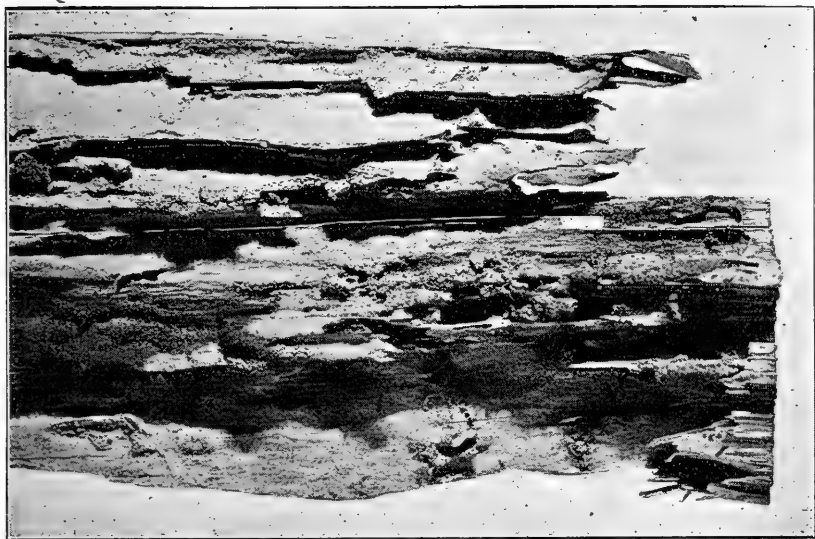


Fig. 17. Termite injury to wood. The interior of this 2x12 joist was riddled by the termites, although the outside surface of the joist showed no injury.

through the mortar between the bricks or stones of a foundation wall, for example, or by constructing covered passages, or runways, over the surface of the wall or other object which they cannot penetrate.

Control. It is very difficult to clean up infestations of *TERMITES* in supports, benches, and walls that are in contact with the soil. If possible the main colony should be located and destroyed by digging out or soaking with kerosene or creosote. In most cases about the greenhouse it will pay to replace the damaged wood with metal, concrete, or brick. At least the wooden supports should rest on footings made

of cement, stone, or brick, and these footings should extend 18 inches above the ground. Hot creosote should be sprayed or painted on the wood nearest the ground. The WHITE ANTS already in the wood will die within a short time if they are not allowed to maintain their connections with the ground and if the wood is thoroughly treated with creosote.

Living plants are seldom attacked unless they are being grown in infested benches or close to an infested wall or post, and the danger to them is ended when the source of infestation is destroyed. Potted plants may be protected by drenching the cinders and boards upon which they are set with 5% kerosene emulsion (p. 109) after the source of infestation has been stopped. Benched plants found to be infested should be removed and burned and the soil treated with 40% nicotine sulfate at the rate of one fluid ounce to four gallons of water.

Additional information on the prevention of damage by WHITE ANTS in buildings of all kinds is given in a circular entitled "Habits and Control of Termites," which may be obtained, upon request, from the Illinois State Natural History Survey at Urbana.

THRIPS

Like almost all greenhouse crops, chrysanthemums are subject to attack by one or more species of THRIPS. These small, narrow-bodied, active insects, which range in color from yellow to brown or almost black, injure both the leaves and the blossoms. Their work on chrysanthemums is described here rather fully because of the importance of this crop in Illinois. The methods of control given in the following paragraphs apply also to other crops except as noted in the sections on roses (p. 82).

Injury. THRIPS have mouth parts that are fitted for piercing and scraping the leaf surface and for sucking the juices and other cell contents as the plant "bleeds." At first, they cause the older leaves to be more or less thickly covered with whitish blotches on the upper surface and minute black specks on the lower surface. Later, as the spots coalesce, the blotches and dead areas show through, and under a severe attack the leaves may wilt and drop from the plant. The injury to the new growth is quite different, the edges of the unfolding leaves being browned as though burned, and the leaves being crippled after they open. The blossoms also are attacked and may be ruined, the petals becoming deformed, streaked, or browned. In addition to the direct injury, THRIPS deposit small drops of a dark, sticky fluid which collects dirt, invites mold, and altogether renders the plant very unsightly.

Unless a constant watch is kept on the plants, and control measures properly executed, THRIPS are capable of causing severe injury within a short time. This is due to their comparatively short life history and to the fact that they feed almost constantly throughout the nymphal and adult stages, with the exception of a short resting period before they become adults.

THRIPS injury on chrysanthemums may be mistaken, in some cases, for the injury caused by RED SPIDERS, and to a lesser extent, for that caused by the CYCLAMEN MITE. However, the long, narrow body of the THRIPS and their fringed wings, together with the absence of spider webs where THRIPS alone are feeding, will serve to distinguish them.

Control. It is extremely important that chrysanthemum stock and other plants in the range be kept free of THRIPS, for cuttings taken from infested stock are almost sure to have eggs imbedded in the leaf tissue. This can be accomplished by weekly applications of a spray, using one ounce of 40% nicotine sulfate to four gallons of water. The addition of soap (one ounce to each gallon) will increase the effectiveness of the spray, but soap should be omitted in spraying unrooted cuttings.

Homemade nicotine dust containing 2.4% actual nicotine is very effective in killing THRIPS in the greenhouse, and it deserves to come into more general use. It can be easily prepared at a cost of from one-third to one-half the cost of commercial dusts. Directions are given on p. 107. It may be applied with an ordinary dust gun, although a duster of the puff type can be more easily handled in the greenhouse.

Any spray or dust should be directed to the under side of the leaves. The use of a dust on stock plants allows for a more thorough coverage where the THRIPS are feeding on the heavy, low growth. When using a nicotine dust, start at the farther end of the bench and work backward, so as to be moving away from the dust and thus avoid breathing much of it.

After chrysanthemums have been benched, the THRIPS may be held in check by dusting, spraying, or fumigating. The best results



Fig. 18. Chrysanthemum leaf injured by thrips.

have been obtained by using 40% nicotine sulfate at the rate of two ounces in three gallons of water, *without soap*. Apply the spray lightly to the under sides of the leaves at dusk.

Weekly fumigations with nicotine or cyanide will do much to keep THRIPS under control, but cannot be relied upon to clean up an infestation quickly, since only the adults are killed in appreciable numbers by dosages safe to use on the plants. In using any of the various forms of nicotine on the market for fumigation purposes, the directions of the manufacturers should be followed until trials in the individual house have shown the proper strength to use. Cyanide in any form should not be used on plants that have recently been sprayed or dusted with a copper compound, such as Bordeaux mixture, for very severe injury will result.

Frequent syringing with clear water, where weather conditions will permit, will aid in holding the THRIPS in check.

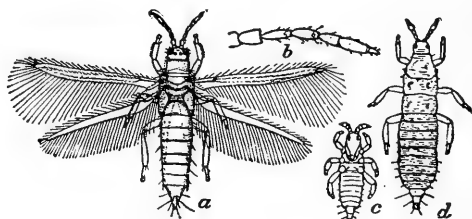


Fig. 19. Adult and nymphs of the onion thrips.

As is true with so many insects, prevention is the keynote of success. The words of Mr. A. F. J. Baur are fitting in this respect, "Always bear in mind that the way to combat insects is to meet them at the threshold and turn them back."

Life History and Habits. There are several species of THRIPS that attack chrysanthemums and other greenhouse crops. The ONION THRIPS³² is by far the most prevalent and injurious species in Illinois, and it is followed by the FLOWER THRIPS³³ and the GREENHOUSE THRIPS³⁴ in order of destructiveness. The several species are so nearly alike in appearance, life history, and habits that only one of them needs to be described here.

The adult of the ONION THRIPS can be easily recognized by the general elongated structure of its body and wings. It is less than 1/10 inch in length and yellow to brown in color (the GREENHOUSE THRIPS is almost black). The fore wings are fringed on the hind margin with long, stiff hairs, or bristles, and with shorter hairs on the front margin. The hind wings are similar, though smaller. When at rest, the wings are folded along the back, giving the insect a very slender appearance. The adults are most active on warm sunny days, when

³² *Thrips tabaci* L.

³³ *Frankliniella tritici* (Fitch).

³⁴ *Heliothrips haemorrhoidalis* Bouche.

they will be seen moving over the upper surface of the leaves. The females are capable of laying fertile eggs without mating.

The eggs are white, nearly transparent, bean-shaped, and so small that it would require 100 or more placed end to end to measure an inch. Each egg is inserted nearly its full length into the under surface of the leaf, usually along one of the veins. They hatch in four to ten days.

The young nymphs, when first hatched, are nearly white, with bright-red eyes, and are so small as to be scarcely visible. They feed on the tissues of the leaf and develop rapidly during the first two stages of growth. They pass the third and fourth stages in the soil and now closely resemble the adults in general shape and color, but have no wings and are sluggish in their movements. After the fourth moult, the adult females are ready to return to the plant and lay eggs for another generation.

Under the most favorable conditions the life cycle may be completed in three weeks, but it averages four weeks in the chrysanthemum house. THRIPS breed throughout the year, and the different broods overlap.

THRIPS feed on many weeds, shrubs, and cultivated crops. They gain entrance to the greenhouse through the open doors and ventilators, often literally swarming in on warm days in the fall of the year, and to a lesser extent in the early spring. They are able to fly only a short way under their own power, but with the aid of a strong breeze they can travel considerable distances.

Whiteflies	p. 16
White Grubs	p. 83
Wireworms	p. 27

CINERARIA PESTS

Cinerarias are subject to insect attack from the time the seedlings are out of the ground until the plants are sold. Any of the eleven pests listed below may prove troublesome in the handling of this crop. APHIDS, CUTWORMS, the GREENHOUSE LEAF TYER, RED SPIDERS, THRIPS, and WHITEFLIES are generally most troublesome. SOWBUGS and MILLIPEDES are especially destructive to the young seedlings. Control measures recommended on the pages to which reference is made in the following list will be found effective on cinerarias also.

Aphids, or Plant Lice	p. 89
Cabbage Looper	p. 22
Cutworms	p. 36
Greenhouse Leaf Tyer	p. 39
Mealybugs	p. 50
Millipedes	p. 92
Red Spiders	p. 75
Scale Insects	p. 59
Slugs	p. 25
Sowbugs	p. 95
Thrips	p. 46
Whiteflies	p. 16

CLARKIA PESTS

Red Spiders	p. 75
Thrips	p. 46

COLEUS PESTS

Several species of MEALYBUGS comprise the major pests of coleus. The GREENHOUSE ORTHEZIA occurs less frequently but is very destructive and difficult to control when once established. MILLIPEDES, SOWBUGS, and WHITEFLIES sometimes become troublesome and are therefore listed below with cross-reference to the places where they are discussed under crops on which they are normally most destructive.

Cutworms	p. 36
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GREENHOUSE ORTHEZIA

The GREENHOUSE ORTHEZIA,³⁵ attacks coleus, lantana, begonia, fuchsia, chrysanthemum, ageratum, and many other crops grown under glass. The insect proper is very minute and dark-green in color but may be easily distinguished from other similar insects by the long waxen tube extending backward from its body. The eggs are laid within this tube. The character of injury is similar to that caused by the MEALYBUGS described below, and the same control measures are recommended.

MEALYBUGS

Coleus and other foliage plants are often found to be harboring MEALYBUGS—small, sluggish, whitish, soft-bodied insects, up to ¼ inch long—in clusters on the undersides of the leaves or in the leaf axils. Host plants include croton, cactus, bay tree, poinsettia, palm, ficus, geranium, and others.

Injury. MEALYBUGS suck the juices from the stems and leaves, discoloring and deforming the foliage. They sometimes attack chrysanthemums and other flowering plants just below the bud and cause the flower to be deformed. Young and tender plants may be killed.

Control. MEALYBUG infestations are more easily prevented than cured. Plants that will stand syringing with a strong stream of clear water may be kept clean in this way. Tender plants should be sprayed with 40% nicotine sulfate at the rate of one ounce to three or four gallons of water, or with nicotine oleate at the rate of one ounce to one or two gallons of water. (For directions for preparing nicotine oleate see p. 107.) Either of these sprays should be used as strong as the

³⁵ *Orthezia insignis* Doug.

plants will stand and should be applied with good pressure. Very tender plants likely to be injured by the spray may be washed with clear water two hours after spraying. It is essential to have stock plants clean before taking cuttings, and it is better to injure the plants somewhat with strong sprays than to tolerate MEALYBUG infestations.

Regular fumigations with calcium cyanide ($\frac{1}{4}$ ounce to 1,000 cubic feet of space) will aid in keeping MEALYBUGS in check but cannot be relied upon to clean up an infestation.

ANTS are attracted to infested plants by the honeydew secreted by the MEALYBUGS and are often responsible for their spread from plant to plant. If ANTS are observed on the plants they should be destroyed (see p. 94).

Life History and Habits. The CITRUS, or COMMON, MEALYBUG³⁶ is most often found in the greenhouse. The waxy filaments circling the body are short and stiff-looking. The LONG-TAILED MEALYBUG³⁷ is similar to the COMMON MEALYBUG but may be easily distinguished by its longer waxy filaments, especially the two very long projections on the hind end of the body. The MEXICAN MEALYBUG,³⁸ which cannot readily be distinguished from the COMMON MEALYBUG, is of recent introduction in Illinois and attacks a number of plants not considered as common host plants for MEALYBUGS. Thus far in Illinois it has been particularly destructive to chrysanthemums and geraniums.

MEALYBUGS are closely related to the SCALE INSECTS, though differing greatly in appearance. They are orange in color but almost completely covered with a white mealy substance and have a fringe of waxy projections about the body. It is this waxy covering which protects them from most insecticides.

The SHORT-TAILED SPECIES reproduces at a rapid rate, each female laying upwards of 600 eggs, all in one cluster, which she covers with a cottony case. The young hatch from the eggs in about 10 days but remain in the case for several days before beginning to crawl over the plants. They feed by sucking the sap, and they grow to be about $\frac{1}{4}$ inch long. The LONG-TAILED SPECIES gives birth to living young, and its rate of reproduction is not so high. Individuals of the latter form are rather active, crawling from one part of the plant to another until ready to start reproduction, when they become more or less stationary. The males of both species are two-winged, fly-like insects; they are unable to feed in the adult stage, and they die soon after mating. The period of one complete generation is about a month.

Millipedes	p. 92
Sowbugs.....	p. 95
Whiteflies	p. 16

CRASSULA PESTS

Mealybugs	p. 50
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³⁶ *Pseudococcus citri* Risso.

³⁷ *Pseudococcus adonidum* Targ.

³⁸ *Phenacoccus gossypii* T. & Ckll.

CROTON PESTS

Mealybugs	p. 50
Scale Insects	p. 59
Thrips.....	p. 46

CYCLAMEN PESTS

The two major cyclamen pests are the CYCLAMEN MITE, which frequently cuts production 50% and is difficult to control, and the THRIPS, which are also very destructive but more easily controlled. EARTHWORMS are a serious nuisance where potted plants are to be removed from the pots for shipment. Seven other pests which sometimes attack cyclamens will be found listed below in alphabetical order, each with a cross-reference to the place where it is discussed under the crop on which it more often occurs.

Aphids, or Plant Lice.....	p. 89
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Fig. 20. Begonia injured by cyclamen mite, shown in contrast with normal plant. The distorted leaves and blossoms are typical of cyclamen mite injury.

CYCLAMEN MITE

The most prevalent and destructive pest of cyclamens in Illinois is the CYCLAMEN MITE,³⁹ sometimes called "THE PALLID MITE" but more frequently known to growers simply as "THE MITE." Although found in the greenhouse throughout the year, it is most active and destructive from August to January. While cyclamen is the preferred host plant, begonia, chrysanthemum, daisy, forget-me-not, fuchsia, geranium, gloxinia, larkspur, petunia, snapdragon and verbena are also attacked.

³⁹ *Tarsonemus pallidus* Banks.

Injury. Leaves and flower buds forming on infested corms become crippled, discolored, and weak. Opened leaves that are attacked become also wrinkled and pocketed; they often have small brown cracks on the upper surface and are russeted underneath. The flower buds in all stages of growth are particularly attractive to the MITES, and a light infestation is sufficient to make the plants unsalable because of the malformation and discoloration of the flowers. Infested seedlings quickly become stunted beyond recovery.

Control. The nature of the CYCLAMEN MITE, together with its habit of feeding in protected places, makes control difficult. The use of insecticides alone should not be relied upon to give satisfactory results. One of the most important factors in control is to practice strict greenhouse sanitation.

Where cyclamens are grown in frames outdoors during the summer, or where plants are purchased in the fall, the house should be thoroughly disinfected before bringing in the plants. Disinfection for this purpose may be accomplished in one of two ways:

(1)—When the house is empty, fumigate with hydrocyanic acid gas, using 10 ounces of sodium cyanide or potassium cyanide, or three pounds of calcium cyanide, to each 1,000 cubic feet of space. (For directions see pp. 102-105.) This method cannot be used where other plants are growing in the same house, and it must be used with care where the house is connected with others containing plants. Fumigation at this strength will kill all forms of plant and animal life not buried in the ground. Before fumigation, benches containing soil should be emptied, or the soil sterilized with steam (see p. 91). If the benches are to be filled with any material, coke screenings or cinders that have been exposed to the elements for a year are recommended. Fresh cinders may cause burned spots and edges on the leaves.

(2)—Where fumigation is out of the question, empty the benches, or sterilize the soil, and spray the benches, walks, and ground under the benches thoroughly, from all sides, with a 5% kerosene emulsion, using sufficient liquid to thoroughly soak all cracks and crevices. (Directions for preparing kerosene emulsion will be found on p. 109.) The practice of treating the empty benches with hot lime is also good.

The growing of cyclamen in the same house with other host plants, as listed above, should be avoided as far as possible.

Experiments with oil emulsions, paradichlorobenzene, and naphthalene for the control of the CYCLAMEN MITE have been carried on in Illinois with very promising results. Infested plants have been almost completely freed of MITES by means of *PDB* applied when the plants

were first transferred from the flats and at intervals of two weeks thereafter. It was found that the burning which resulted from the broadcasting of *PDB* flakes over the plants could be avoided by the use of pressed balls of *PDB* of the same size as ordinary moth balls. These pressed balls, which are obtainable on the market, give off a lower concentration of gas over a longer period of time than the flakes. One ball placed on the surface of the soil in each pot controlled the MITES satisfactorily without injury to the plants. Replacing the *PDB* balls every two weeks, however, involves a great deal of labor when large numbers of plants must be treated, and the experiments are being continued. The results at present do not justify unqualified recommendations.

A nicotine spray applied at intervals of ten days or two weeks will aid in controlling the MITES, killing all those that are exposed at the time of application. This spray is made up with one ounce of nicotine sulfate and two ounces of light oil emulsion in three gallons of water.

Life History and Habits. The MITE itself is very minute and nearly transparent. The females outnumber the males about eight to one during the winter months, although the percentage of males increases during the summer. Each female lays one to four eggs a day over a period of 10 to 20 days and is capable of laying eggs without fertilization. The eggs, which are so minute that they cannot be distinguished without the aid of a lens, are oval in shape and glossy white in color. They are laid at night on the undersides of the leaves, between the sepals and petals of the flower buds, or on the surface of the corms. They hatch into small MITES in two to seven days, depending on the temperature and relative humidity. The MITES thrive best at temperatures above 60°F. and with a relative humidity of 80 to 90%. After two or three days the young MITES enter a quiescent period, lasting from one to four days, before they emerge as adults. In the quiescent stage they do not feed and are very resistant to all insecticides. Completion of the life cycle under favorable conditions thus requires from one to two weeks.

EARTHWORMS

Several species of EARTHWORMS are often a nuisance on cyclamen and other stock, especially on young plants which are to be removed from the pots for shipment.

Injury. By tunneling near the side of the pot, the EARTHWORMS leave a trail of slime which causes the dirt to stick to the pot, so that the plant cannot be removed without breaking the dirt ball. Their habit of tunneling through the network of the roots of plants is very injurious at times. EARTHWORMS breed rather rapidly in the greenhouse. The eggs, which are yellowish-brown in color and resemble small sweet pea seeds in size, are laid in the soil. Occasionally the greenhouse benches literally swarm with the WORMS, so that special

treatment is necessary to prevent the soil from becoming soggy, hard, and porous.

Control. The only sure method of controlling EARTHWORMS in pots is to sterilize the soil with steam before it is used. (See p. 91.) For this work it is not necessary to heat the soil so long as for the control of EELWORMS. A temperature of 130° to 135°F. for one hour is effective. The numbers of these pests may be reduced by watering the soil with corrosive sublimate in solution as directed for the control of the maggots of FUNGUS GNATS (p. 57). A light application of flake naphthalene on the soil surface of potted plants will tend to drive the WORMS from the pots, and this treatment may be used with safety on the more hardy plants, such as cyclamen. Clean plants set on infested soil will soon become infested. When troublesome in benches, these pests may be killed by a light application of hydrated lime worked into the soil surface and followed by watering.

Eelworms (p. 90) cause large swollen areas on cyclamen root systems. Infested plants and soil should be burned, and the pots should be sterilized with steam (p. 91) before being used again.

Greenhouse Leaf Tyer	p. 39
Millipedes	p. 92
Mites, see Cyclamen Mite	p. 52
Sowbugs	p. 95

Thrips (p. 46) cause the foliage of cyclamen plants to become russeted and the flowers to become streaked in a manner that may be mistaken for MITE injury, but the leaves are not crippled. Nicotine dust or sprays will control the THRIPS in this instance as in others.

White Grubs	p. 83
Wireworms	p. 27

CYPERUS PESTS, *see* UMBRELLA PLANT PESTS, p. 99.

DAFFODIL PESTS, *see* BULB PESTS, p. 19.

DAISY PESTS, *see* MARGUERITE PESTS, p. 64.

DELPHINUM PESTS, *see* LARKSPUR PESTS, p. 64.

DIANTHUS PESTS, *see* CARNATION PESTS, p. 22.

DIDISCUS PESTS, *see* LACE FLOWER PESTS, p. 64.

DRACAENA PESTS

Mealybugs	p. 50
Thrips	p. 46

EASTER LILY PESTS, *see* BULB PESTS, p. 19.

EUPHORBIA PESTS

Scale Insectsp. 59

FERN PESTS

Various SCALE INSECTS, which may become destructive at any season of the year, are the major pests of ferns. A brief account of the injury they do, together with recommendations for control measures and notes on their life history and habits, with particular reference to the four chief offenders, is given in this section. The FLORIDA CUTWORM and the FUNGUS GNATS are sometimes of major importance and are discussed here at some length. Eight other pests that attack ferns at one time or another are also listed, each with a cross-reference to the place where it is discussed in connection with the crop on which it is more often found. Of this latter group of pests the MEALYBUGS and SLUGS are likely to prove most troublesome.

Cutworms, p. 36; *see also* Florida Fern Cutworm *below*.

Eelwormsp. 90

FLORIDA FERN CUTWORM

The FLORIDA FERN CUTWORM⁴⁰ gains entrance to the greenhouse, in the egg, larva, or pupa stage, by being carried on shipments of ferns, chiefly from southern points. It is a green-to-black, cutworm-like caterpillar, up to 1½ inches long, capable of completely stripping large ferns of their leaves within a few days. It is not often a very destructive pest in Illinois, however, for most greenhouse men in the state are acquainted with this insect and its work and usually get it under control at once.

Injury. The fronds are rapidly devoured by the larvae, the older ones being disfigured by the loss of leaflets and the younger ones being entirely eaten away. Infested plants soon become unfit for sale.

Control. If the infestation is light, simply picking the larvae off the ferns by hand at night with the aid of a flashlight is satisfactory. Where their numbers are sufficient to warrant special control measures, pyrethrum has been found very effective by Gibson and Ross,⁴¹ who recommend dusting with fresh pyrethrum powder twice a week or applying the following spray once a week:

Fresh pyrethrum powder.....	8 ounces
Laundry soap	4 ounces
Soft water	8 gallons

⁴⁰ *Callopistria floridensis* Guen.⁴¹ Dominion of Canada, Dept. of Agr., Bull. No. 7, 1922.

First dissolve the soap in a small quantity of warm water, and then add the pyrethrum powder and enough water to make eight gallons of mixture. Weekly applications should be made until the infestation is cleaned up.

The poison bait described on p. 107 is inexpensive and will aid also in the control of this pest.

Life History and Habits. The adult of the FLORIDA FERN CUTWORM is a beautifully marked moth with a wing expanse of one inch. The general color of the front wings is brown, with dark-reddish-brown patches bordered by lighter areas. The hind wings are almost uniformly brown. The eggs are laid singly on the under surface of the leaves. The larvae, which hatch from the eggs within a week, are light-green at first and become somewhat darker green or black when mature, being then about $1\frac{1}{2}$ inches in length. They have the general appearance of CUTWORMS and are nocturnal in habit. During the day they usually will be found buried just below the surface of the soil at the base of the ferns, although the younger stages often remain at rest all day on the midrib of the fronds.

FUNGUS GNATS

If ferns or other plants are sickly, with no visible cause above ground, examine the roots for brown scars and tunnels made by small, white, thread-like footless maggots with dark heads. These maggots are the larvae of FUNGUS GNATS, of which the FICKLE MIDGE⁴² is a common example. Their principal food is found in fresh manure and fungus growths, such as mushrooms, and they are often seen in large numbers soon after an application of fresh manure to the benches. As long as there is a supply of moist manure they are not likely to attack the living roots. In their younger stages they may easily be mistaken for EELWORMS, and later they may be confused with the true WORMS found in soil rich in organic matter, the latter being also small, white, thread-like and footless, but harmless. Besides ferns, on which they are most destructive, these pests also attack carnations, begonia, coleuses, sweet peas, roses, lupines, and many other greenhouse plants.

Injury. In addition to the direct injury caused by the maggots burrowing into the roots there is even more serious damage done to the plants by disease organisms that find the burrows an ideal place to enter and develop. Carnation cuttings are often destroyed soon after being transferred to pots from the propagating bench. Seedlings of many kinds are killed outright, and mature plants in general are weakened. The adult GNATS may become a serious nuisance to the grower of very hairy plants, such as lace flowers and lupines, for they collect

⁴² *Sciara inconstans* Fab.

on the flower stalks, where they die and are retained by the hairs, so that each flower stalk must be brushed before it can be sold.

Control. The adults are readily killed by fumigation with nicotine or calcium cyanide at the usual strength. Nicotine fumigations are preferred for use on ferns because of their susceptibility to injury by hydrocyanic acid gas.

As a means of controlling the maggots, a dilute solution of corrosive sublimate (mercuric chloride) has been successfully used in Illinois



Fig 21. Adult fungus gnats on the stems of lace flower. It is sometimes necessary to brush the stems of hairy plants to rid them of these insects before they can be sold.

for watering potted ferns and carnation cuttings. One ounce of corrosive sublimate is dissolved in a small quantity of hot water and diluted to 10 gallons. For smaller amounts it is convenient to use two mercuric chloride tablets (7.3 grains each, obtainable at any drug store) to each quart of water. Since mercuric chloride corrodes all metals, the solution should be handled in glass, earthenware, or wooden receptacles.

Tobacco dust containing at least 1% nicotine is also effective when worked into the soil.

Life History and Habits. The adults are very tiny, gray-to-black, two-winged flies, resembling small mosquitoes. Each female lays from 100 to 200 eggs, in small clusters, in the soil. The larvae hatch in about a week and work their way through the soil or into the roots. They become mature when one week old and are then about $\frac{1}{4}$ inch long. They pupate in the ground, forming cocoons and resting for almost another week before emerging as adults. About one month is thus required for a complete life cycle in the greenhouse at fern temperatures and five weeks or longer at sweet pea temperatures.

Mealybugs	p. 50
Millipedes	p. 92

SCALE INSECTS

Ferns are subject to attack by several species of SCALE INSECTS at all times of the year. Because of the small size and protective coloration of some SCALES, they may go unnoticed until considerable damage is done. The grower, therefore, will do well to keep a constant watch for various tan, greenish-brown, or dark-brown scales on the leaves, usually on the under side or along the midrib.

Injury. All species of SCALE INSECTS injure ferns in the same way: at first, minute yellow blotches appear on the leaflets where the juices have been sucked from the cells; later the whole leaf becomes yellow and dies, and the entire plant looks sickly.

Control. It is much easier to keep ferns free from SCALES than to stop an infestation once established. Since SCALE INSECTS thrive best under dry conditions, there should always be plenty of moisture in the fern house. Before new plants or boarders are brought in, they should be carefully examined, and if infested they should be isolated until cleaned up.

Badly infested leaves should be removed and burned. Then spray the plants with 40% nicotine sulfate, using one ounce to three gallons of soft water in which there has been dissolved three ounces of fish oil soap or laundry soap. This spray should be applied at weekly intervals not more than two hours before watering. It is important to wash the leaves thoroughly when watering, to prevent burning.

Fumigation with nicotine will also aid in controlling SCALE INSECTS, especially those hatching from eggs. When the eggs of the HEMISPHERICAL SCALE are hatching, the young are readily killed by ordinary nicotine fumigation.

Certain proprietary oil emulsions may be used to reduce a heavy infestation, but great care must be taken with any spray containing oil, since ferns are very susceptible to injury.

Ferns used in the household may be cleaned of SCALE INSECTS by drenching the plants with 40% nicotine sulfate used at the rate of one ounce to three gallons of soft water containing three ounces of laundry soap. Small ferns may be dipped in a pail or bucket containing this solution, by inverting the plant and spreading the fingers of one hand so as to hold the dirt in the pot. All the leaves should be immersed for about two minutes. After two hours repeat the operation with clear water, in order to prevent any chance of injury. Ferns too large to dip should be removed to the basement or outdoors and sprayed thoroughly. Elevate the plant or turn it on its side, so that both the upper and lower sides of the leaves will receive the spray. Do not neglect to syringe thoroughly with clear water after about two hours. Weekly treatments should be given until the plants are clean. The same treatments will effectively control APHIDS, or PLANT LICE, THRIPS, and other sucking insects commonly infesting house plants.

Life History and Habits. For practical purposes all SCALE INSECTS infesting ferns have similar life histories. Either the eggs are laid under the mother scale, or the living young are deposited there. In most cases the generations so overlap that there are no definite broods. When the eggs hatch, the young crawl from beneath the mother scale and seek a suitable place to settle down and feed. Most female scales remain in the same position the remainder of their lives, but some retain the power of locomotion for a considerable length of time. Some females have wings, and when mature they mate with the male scales, which are usually white or yellowish and always have wings. The following species are most often encountered on ferns in Illinois greenhouses.

The common FERN SCALE⁴³ is a very small species usually found on the under side of the leaves. The females are difficult to see, for they are light-brown or greenish-brown and blend with the color of the leaflets. The males, which are white, elongated, and readily seen on the green foliage, are short-lived and do not injure the ferns as do the females.

The SOFT BROWN SCALE⁴⁴ is larger and more fleshy than the FERN SCALE but smaller than the HEMISPHERICAL SCALE described below. The females vary in color from a yellowish brown to a deep brown, and they are most often observed along the midrib of the fern leaf. They give birth to living young. While particularly injurious to ferns, they also feed on palms, ficus plants, bay trees, and other ornamentals.

The HEMISPHERICAL SCALE⁴⁵ is dark-brown, smooth, strongly hemispherical, and larger than any of the other scales found on ferns. It also attacks palms, ficus plants, alternantheras, etc. If a female of this species is carefully lifted from the fern leaf and examined on the underside with the aid of a hand lens, numerous minute eggs will be seen. The production of eggs, together with the small white dots on the back of the adult, which are visible under the lens, will serve to distinguish this species from the SOFT BROWN SCALE.

⁴³ *Hemichionaspis aspidistrae* Sign.

⁴⁴ *Coccus hesperidum* L.

⁴⁵ *Saissetia hemisphaerica* Targ.

The CAMELLIA SCALE,⁴⁶ which is less common than the species mentioned above, may be distinguished from most other scales found on ferns by the pronounced median line on its back and by its rather flat, wrinkled surface. This scale also infests ficus and camellia plants and Kentia palms.

Slugs	p. 25
Sowbugs	p. 95
Thrips	p. 46

FEVERFEW PESTS

Marguerite Fly	p. 32
Red Spiders	p. 75
Thrips	p. 46

FICUS PESTS

Scale Insects	p. 67
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FORGET-ME-NOT PESTS

Cyclamen Mite	p. 38
Greenhouse Orthozia	p. 50
Mealybugs	p. 50
Keep plants removed from coleus, ferns, poinsettias, and other crops susceptible to MEALYBUG attack.	
Whiteflies	p. 16

FREESIA PESTS

Aphids, or Plant Lice	p. 89
Red Spiders	p. 75
Slugs	p. 25
Thrips	p. 46

FUCHSIA PESTS

Aphids, or Plant Lice	p. 89
Cyclamen Mite	p. 38
Mealybugs	p. 50
Thrips	p. 46
Whiteflies	p. 16

GALTONIA PESTS, *see* BULB PESTS, p. 19.

GARDENIA PESTS

Aphids, or Plant Lice	p. 89
Mealybugs	p. 50
Slugs	p. 25
Sowbugs	p. 95
Tarnished Plant Bug	p. 43

⁴⁶ *Fiorinia floriniac* Targ.

GERANIUM PESTS

Although geraniums are less subject to attack by insects than most greenhouse crops, there are several pests that frequently cause trouble. FULLER'S ROSE BEETLE, while it seldom does any considerable harm in Illinois greenhouses, is often found on geraniums in the fall of the year and, because of its relatively large size and prominent snout, attracts a great deal of attention. The more serious pests of geraniums include the CABBAGE LOOPER, various CUTWORMS—particularly the VARIEGATED CUTWORM—the CYCLAMEN MITE, the GREENHOUSE LEAF TYER, THRIPS, and WHITEFLIES. In addition,

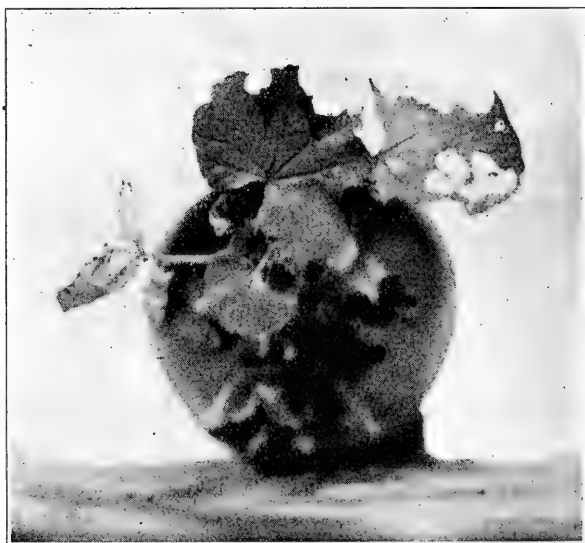


Fig. 22. Geranium leaves eaten away by slugs.

COCKROACHES, EELWORMS, MEALYBUGS, SLUGS, and TERMITES sometimes attack geraniums. Page references are given in the following list for the reader's convenience in finding the places where these pests are discussed under the crops on which they are usually more destructive.

Cabbage Looper	p. 22
Cockroaches	p. 73
Cutworms	p. 36

Cyclamen Mite (p. 52) may be controlled on geraniums by means of a spray made with one ounce of 40% nicotine sulfate solution and four ounces of laundry soap in four gallons of soft water.

Eelworms (p. 90) often attack geraniums. When re-potting, burn all the infested plants, together with the soil in which they have been growing. The clean plants should be put into clean pots with soil that is known to be clean or that has been sterilized. It is also very important to set the pots on a clean bench.

FULLER'S ROSE BEETLE

FULLER'S ROSE BEETLE,⁴⁷ a large, grayish-brown beetle with a prominent snout, occasionally injures geraniums, carnations, roses, camelias, and a few other plants. It is not a serious pest in Illinois but frequently attracts attention because of its comparatively large size and peculiar snout. The adults, which are not able to fly, sometimes crawl into the greenhouse. They feed by chewing holes in the leaves of the plants. The larvae, which are sometimes carried in with a change of soil, feed on the roots in much the same manner as white grubs. The most practical control is to hand-pick the adults when they are found feeding on the foliage.

Greenhouse Leaf Tyer.....p. 39

Mealybugs (p. 50), particularly the MEXICAN MEALYBUG, may cause very severe injury to geraniums. In fact, they are capable of killing the plants if not speedily brought under control.

Slugsp. 25

Thrips.....p. 46

Termitesp. 44

Whitefliesp. 16

GERBERA PESTS

Red Spidersp. 75

Thrips.....p. 46

Whitefliesp. 16

GLADIOLUS PESTS

Aphids, or Plant Lice.....p. 89

Red Spidersp. 75

Slugsp. 25

Thrips.....p. 46

GLOXINIA PESTS

Cyclamen Mitep. 38

Mealybugsp. 50

Thrips.....p. 46

HELIOTROPE PESTS

Greenhouse Orthoziap. 50

Mealybugsp. 50

⁴⁷ *Pantomorus fulleri* (Horn)

HYACINTH PESTS, *see* BULB PESTS, p. 19.

HYDRANGEA PESTS

Red Spidersp. 75

JERUSALEM CHERRY PESTS

Eelwormsp. 90

Red Spidersp. 75

JONQUIL PESTS, *see* BULB PESTS, p. 19.

LACE FLOWER PESTS

Fungus Gnatsp. 57

Red Spidersp. 75

LANTANA PESTS

Red Spidersp. 75

Scale Insectsp. 59

Thrips.....p. 46

Whitefliesp. 16

LARKSPUR PESTS

Cyclamen Mitep. 38

Red Spidersp. 75

LATHYRUS PESTS, *see* SWEET PEA PESTS, p. 89.

LEMON PESTS

Mealybugsp. 50

Scale Insectsp. 59

LILY PESTS, *see* BULB PESTS, p. 19, *and* CALLA LILY PESTS, p. 22.

LUPINE PESTS

Fungus Gnatsp. 57

Red Spidersp. 75

MARGUERITE PESTS

Eelwormsp. 90

Marguerite Fly.....p. 32

Red Spidersp. 75

MATHIOLA PESTS, *see* STOCK PESTS, p. 87.

MIGNONETTE PESTS

Cabbage Looperp. 22

MYOSOTIS PESTS, *see* FORGET-ME-NOT PESTS, p. 61.

NARCISSUS PESTS, *see* BULB PESTS, p. 19.

ORCHID PESTS

Orchids are not subject to serious attack by many pests, though the SCALE INSECTS are generally prevalent and injurious. The ORCHID FLY, or CATTLEYA FLY, may cause severe losses and undoubtedly would frequently if growers did not take care to destroy suspicious-looking buds. MEALYBUGS, SLUGS, and SOWBUGS are sometimes troublesome, and several WEEVILS have been recorded as feeding on orchids. These are included in the following alphabetical list, each with a number referring to the page where the pest is discussed in connection with the crop on which it is most often found.

Cattleya Fly, see Orchid Fly below.

Mealybugsp. 50

ORCHID FLY

The ORCHID FLY,⁴⁸ known to many growers as the CATTLEYA FLY, is sometimes a serious pest. Previously, when orchids were largely brought in from the tropics, this and other orchid pests were far more troublesome than at present. Since introductions became less frequent, the losses occasioned by the ORCHID FLY are no longer so great as formerly.

Injury. The flower buds become abnormally swollen at the base, fail to develop, are darkened, and usually die after the adult flies emerge.

Control. The most important factor in control is the obtaining of clean stock. Any new stock purchased should be thoroughly examined for suspicious swelling of the buds. If the swelling occurs after the plants are in the orchid house, the infested buds should be removed and burned. At the present time no other control measures are necessary in Illinois.

Life History and Habits. The adult is a clear-winged wasp about $\frac{3}{8}$ inch in length. The eggs are laid in the buds, which begin to swell shortly after the larvae hatch. The entire life cycle is completed in about two months, and the adults emerge to live but a few days. This insect is unable to survive outside the greenhouse.

SCALE INSECTS

The SCALE most frequently encountered on orchids in Illinois is the OLEANDER SCALE⁴⁹ (p. 68), though the ORCHID SCALE⁵⁰ is also common. The latter is somewhat similar to the FLORIDA RED SCALE (p. 68) but lighter in color and somewhat larger.

⁴⁸ *Eurytoma orchidearum* (Westw.).

⁴⁹ *Aspidiotus hederae* (Vall.).

⁵⁰ *Parallelopiplosis cattleyae* Moll.

Injury. At first, minute whitish blotches appear on the leaves where the scales have sucked the juices from the cells. Later the flowers are weakened. Badly infested plants may shrivel up and die.

Control. The same control measures are recommended as for the control of scales on ferns (p. 59). It is hardly necessary to warn against the use of oil or nicotine sprays on orchids when the plants are in bloom, for the danger is well known to all growers.

The *life history* of scale insects is described on page 60.

Slugs (p. 25), which are particularly injurious to the roots of orchids, may be controlled by applying lime or nicotine dust to the benches and racks.

Sowbugs (p. 95) also cause severe injury to orchids and may go unnoticed for a long time because they hide among the roots.

Weevils, or small **SNOUT BEETLES**,⁵¹ are not known to be troublesome to orchid growers in Illinois, although several species have been reported from other states as capable of causing severe injury at times.

PALM PESTS

Nine species of **SCALE INSECTS** make up the major pests of palms. A brief description of the forms commonly found in Illinois greenhouses is given here and is preceded by notes on the general type of injury and recommendations for control. The **COCONUT MEALYBUG** and occasionally other species of mealybugs sometimes attract attention on palms but seldom become serious pests of palms in the greenhouse. They may, however, become serious pests in conservatories and private homes where the plants are not properly syringed.

Mealybugs (p. 50), if found at all on palms, are almost certain to belong to the species known as the **COCONUT** or **PALM MEALYBUG**,⁵² which is easily distinguished by the checkered arrangement of the waxy secretions on the back. Infestations are not very common in greenhouses but are more likely to occur in conservatories or private homes where the plants are not subject to routine control measures. Thorough syringing with clear water will dislodge both the adults and the young. The oil emulsion recommended below for control of **SCALE INSECTS** on palms will also kill the young **MEALYBUGS**.

Millipedesp. 92

⁵¹ Members of the family **CURCULIONIDAE**.

⁵² *Pseudococcus nipae* Mask.

SCALE INSECTS

Palms are susceptible to attack by numerous species of SCALE INSECTS, some of which are found also on citrus, ficus, oleander, and related plants. It is seldom necessary for the grower to identify the species, however, since the same control measures are effective on one as well as another.

Injury. Since all SCALE INSECTS obtain their food by extracting the cell sap, they rob the plant of some of its strength. Although a single scale takes but a small amount, a heavy infestation soon exhausts the life of the plant. When infested plants are freed of SCALES, the whitish or yellowish blotches marking the feeding places remain for some time.

Control. Experiments conducted in Illinois have shown that palms, ficuses, and similar plants may be completely freed of the more common SCALE INSECTS with a single thorough application of boiled lubricating-oil emulsion at 1.5% strength. (Directions for preparing the stock emulsion are given on p. 109.) It may be necessary to repeat this treatment after a week or ten days in order to kill the more resistant species. The only danger of injury to palm and rubber plants by such a spray is on very bright days in mid-summer, and this may be avoided by a thorough syringing two hours after the spray has been applied. For mixing large amounts, use $1\frac{1}{2}$ gallons of the stock emulsion to 100 gallons of water. For smaller amounts, it is more convenient to purchase a stock emulsion and use it according to the directions supplied by the manufacturers.

Several proprietary oil emulsions on the market give good results when used at the strength recommended by the manufacturers for the control of SCALE INSECTS on palms. The homemade emulsion is to be preferred in most cases, however, since most of the proprietary compounds gum up the leaf surface and collect and retain dust and dirt.

Potash fish-oil soap used at the rate of one pound in three gallons of water is effective when three or four applications are made at weekly intervals. The plants should be syringed with clear water two hours after each application.

When only a few plants are to be treated, "Lemon Oil," a proprietary compound which should not be confused with the oil of lemon, may be used to advantage. This compound emulsifies when added to water and should be used at the strength recommended by the manufacturers. Several treatments at intervals of two weeks are usually necessary to bring the SCALES under control, since this spray is not very effective against the eggs.

Life History and Habits. All scale insects have similar life histories (p. 60).

The FLORIDA RED SCALE⁵³ is one of our most common and destructive scales on all varieties of palms. It also attacks acacia, citrus, ficus, and oleander plants. Its body is nearly black, circular, and rather flat with a slightly raised center which is red. It is usually to be found on both the upper and lower surfaces of the leaves. Another closely related species, the CALIFORNIA RED SCALE,⁵⁴ looks much like the FLORIDA RED SCALE but may be generally distinguished by its semi-transparent covering and its bright-reddish-brown color. The eggs are laid under the female scale.

The TESSELLATED PALM SCALE⁵⁵ occurs on palm, ivy, oleander, orchid, ficus, and other plants. It is readily distinguished from other scales found on palms by its flat, oval shape, its greenish-black color, and its checkered, or tessellated, surface. The females give birth to living young.

The GREEDY SCALE⁵⁶ is often found in colonies on citrus, palm, and ficus plants. This scale, which has a rather highly convex surface, is not so easily identified by the grower, but its habit of collecting in colonies is characteristic.



Fig. 23. Florida red scale.

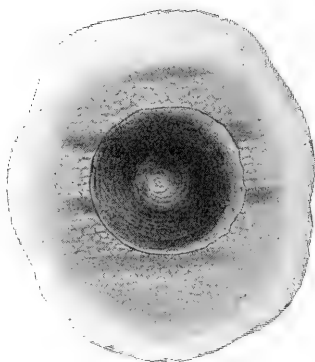


Fig. 24. Oleander scale, greatly enlarged.

The LATANIA SCALE,⁵⁷ found on citrus and latania as well as on palm, looks much like the GREEDY SCALE since it has a highly convex surface, but it is not so apt to collect in clusters, and when it is removed from the host plant the under side of the scale will be seen to be well developed, retaining the insect within.

The PALM SCALE,⁵⁸ a reddish-brown species, not well marked but noticeable for the amount of sweet sticky substance it secretes, is very prolific on palms and rather difficult to bring under control when thoroughly established.

The IVY, or OLEANDER SCALE⁵⁹ occurs principally on ivy, palm, oleander, and orchid plants. This scale also collects in clusters and may completely cover the

⁵³ *Chrysomphalus ficus* Ashm.

⁵⁴ *Chrysomphalus surantii* (Mask.).

⁵⁵ *Eucalymnatus tessellatus* (Sign.).

⁵⁶ *Aspidiotus rapae* Cornst.

⁵⁷ *Aspidiotus lataniae* Sign.

⁵⁸ *Chrysomphalus dictyospermi* (Morgan).

⁵⁹ *Aspidiotus hedere* (Vall.).

leaves and stems of the plant. The males, which are white, are frequently more abundant than the females, which are circular, nearly flat, and light tan or gray in color with a brighter, more yellow center. The pale-yellowish eggs are deposited under the scale.

The CHAFF SCALE⁶⁰ is common in Illinois greenhouses on orange and lemon foliage. It is nearly circular in shape and carries the more or less distinct cast skin at the rear end. The young and the eggs are purple and can be readily noticed by carefully lifting the parent scale.

The THREAD SCALE⁶¹ is easily recognized by its long slender form, black color, and small size. It usually lies parallel to the larger leaf veins and, once established, is difficult to control. Among the many plants attacked by it, palms are most susceptible to injury. The eggs are laid under the edge of the female scale.

PANDANUS PESTS

Mealybugs	p. 50
Scale Insects	p. 59

PANSY PESTS, *see* VIOLET PESTS, p. 101.

PELARGONIUM PESTS, *see* GERANIUM PESTS, p. 62.

PERIWINKLE PESTS, *see* VINCA PESTS, p. 99.

PETUNIA PESTS

Red Spiders	p. 75
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PIQUERIA PESTS, *see* STEVIA PESTS, p. 87.

POINSETTIA PESTS

Mealybugs	p. 50
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PRIMROSE PESTS

Aphids, or Plant Lice	p. 89
Greenhouse Leaf Tyer	p. 39
Red Spiders	p. 75
Thrips	p. 46
Whiteflies	p. 16

RESEDA PESTS, *see* MIGNONETTE PESTS, p. 64.

ROSE PESTS

Roses, comprising 50% of the entire cut-flower crop in Illinois greenhouses, are attacked by numerous insects, of which the most destructive are several species of LEAF TYERS, LEAF ROLLERS, RED SPIDERS, THRIPS, and the ROSE MIDGE, any one of which is capable of causing equally severe damage to the rose crop if not held in check. Next in order of relative destructiveness are the APHIDS, the STRAWBERRY ROOT WORM,

⁶⁰ *Parlatoria pergandei* Comst.

⁶¹ *Ischnaspis longirostris* Sign.

and various WHITE GRUBS. Other pests of lesser importance on roses include COCKROACHES, SOWBUGS, MILLIPEDES, and SYMPHYLIDS, or CENTIPEDES. On the following pages the major pests are discussed in alphabetical order. The injury done by each pest is described, measures are recommended for its control, and brief notes are given on its life history and habits. Similar information on the other pests mentioned will be found on the pages indicated after each name in the alphabetical list.

Aphids (p. 89) on roses are not limited to one species, but the ROSE APHID,⁶² a kind of "GREENFLY" which feeds in colonies, usually on the terminal shoots, is the chief offender. If allowed to become abundant, these plant lice will feed also on the undersides of the leaves. The infested portions of the plants become stunted and crippled, and the flower buds either drop or fail to open normally. Plants severely injured are slow to recover. Fumigation with nicotine or calcium cyanide is the preferred means of control.

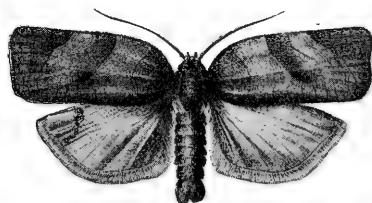


Fig. 25. Adult of the rose leaf roller.

CATERPILLARS

Four species of small, pale-green, lightly striped or spotted caterpillars are frequently found on roses grown under glass in Illinois. The GREENHOUSE LEAF TYER already described in the section on chrysanthemums (p. 39) is usually the most destructive one of the four. The next in order of importance is the OBLIQUE-BANDED LEAF ROLLER,⁶³ which is sometimes called the ROSE LEAF ROLLER because it is chiefly a rose-infesting insect, although it does serious injury also to carnations and asters. The other two, the ROSE LEAF TYER⁶⁴ and the ROSE BUD WORM,⁶⁵ are minor pests whose life histories and habits are very similar to those outlined below for the OBLIQUE-BANDED LEAF ROLLER. Since the same control measures in general apply to all these caterpillars, it is usually not necessary for the operator to distinguish one from the other in order to protect the rose crop against their attacks.

⁶² *Macrosiphum rosae* L.

⁶³ *Cacoecia rosaceana* Harr.

⁶⁴ *Cacoecia parallela* Rob.

⁶⁵ *Hedra ochroleucana* Hb.

Injury. Both the leaves and the buds may be injured. Some of the caterpillars feed on the under surface of the leaves, others eat holes through to the upper surface, and still others, particularly the ROSE BUD WORM, may eat into the buds. They also disfigure the plants by rolling or tying together the leaves, more or less in the manner described for the GREENHOUSE LEAF TYER. The OBLIQUE-BANDED LEAF ROLLER is the worst offender in this respect. The folded or tied leaves do not develop normally, and those that have been fed upon may turn brown and fall from the plant. The injured buds, of course, are a total loss.



Fig. 26. Rose shoots injured by rose leaf roller.

Control. Light-traps, sprays, and dusts, as recommended for the control of the GREENHOUSE LEAF TYER on chrysanthemums (p. 39), are effective against this whole group of related pests on roses. The 85-15 sulfur-lead dust is particularly good. In addition, it may be necessary to resort to hand-picking if the caterpillars have begun to work on the buds before the spray or dust has been applied. All specimens seen when the plants are being pruned, tied up, or disbudded, should be destroyed at once.

Life History and Habits. The adult of the ROSE LEAF ROLLER is a light-reddish-brown moth slightly larger than the GREENHOUSE LEAF TYER, the expanse

of its wings being a little more than an inch. Three dark-brown bands—one obscure and two distinct—run obliquely across its wings, and for this reason it is called the OBLIQUE-BANDED LEAF ROLLER. It may be further distinguished by its characteristic bell-shape outline when at rest. Like most moths, it usually remains in hiding during the day and is active only at night or on very dark days.

The eggs are laid on the upper side of the leaf in clusters of 5 to 125, usually about 100 eggs to a mass. Each female moth lays 500 to 700 eggs, over a period of two or three weeks, and about two weeks are required for the eggs to hatch in the rose house.

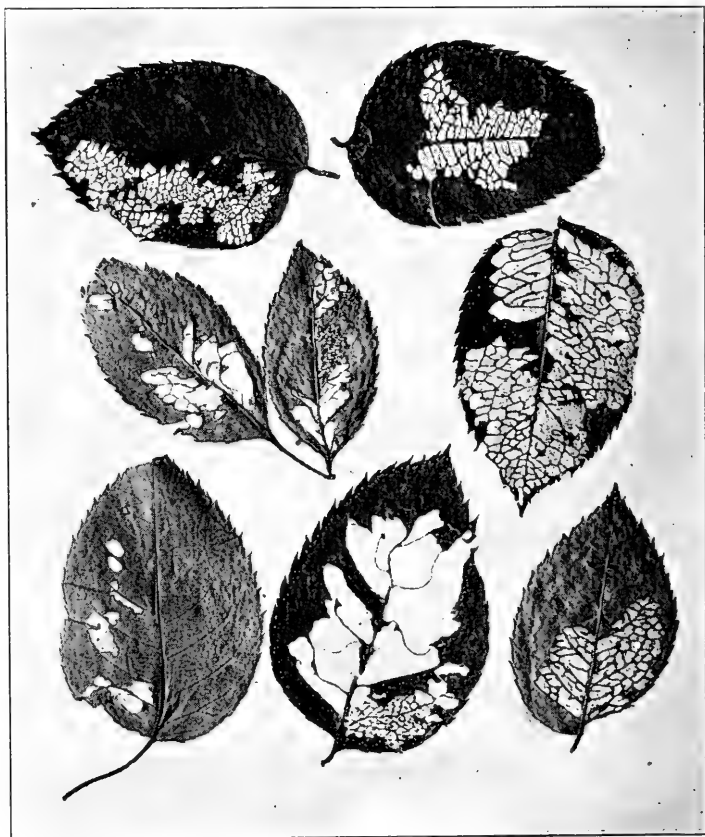


Fig. 27. Rose leaves skeletonized by the greenhouse leaf tyer. The center leaf in the bottom row shows where the upper epidermis of the leaf has died and dropped out.

Soon after hatching, the larvae begin to feed as LEAF MINERS, and later eat off the under surface of the leaves. When disturbed, they lower themselves on slender threads of silk, and in this way they also spread from the plant on which the eggs were laid. In about four weeks they become full-grown and are then

about $\frac{3}{4}$ inch in length and olive-green in color, except that the head is pale-brown and there is a dark-green line down the middle of the back. When ready to change into the pupal stage, each caterpillar makes a shelter for itself by rolling or folding a leaf and spinning a light web.

The pupa of this species may be distinguished from other pupae found in similar locations by the presence of four peculiar hooks at its tip. After two weeks in the pupal stage the adults emerge.

Nearly two months are required to complete the life cycle at temperatures usually maintained in the rose house.

Beetles, see Fuller's Rose Beetle, p. 63, and Hausermann's Rose Beetle, p. 74.

Centipedes, see Symphylids.....p. 96

COCKROACHES

By feeding on roses, chrysanthemums, geraniums, and other plants, COCKROACHES are capable of causing serious trouble in greenhouses at any season of the year and especially during the spring months. These large, oval, brown, active insects, with or without wings, that scurry for shelter when exposed to the light, may become very abundant in houses not kept in sanitary condition. They breed in moist places, such as heaps of rubbish around the benches, and they are likely to congregate in the engine room or other places where they can feast on crumbs scattered by employees at lunch. They become most troublesome where leaky steam pipes and gutters allow water to accumulate, for they require considerable moisture in order to live and multiply.

Injury. These pests girdle the stems of roses near the ground and eat out the "eyes" of plants that have been resting. They are particularly fond of young grafted stock.

Control. COCKROACHES can be prevented from multiplying by the practice of strict greenhouse sanitation, and their numbers can be reduced by the use of poisons, as follows:

Powdered sodium fluosilicate or sodium fluoride, liberally scattered wherever the pests are found, especially in dark corners and under leaky steam pipes, will kill those that come in contact with the powder or run through it. These materials, however, because of their injurious effects on plant roots, should never be used on the benches or on shelves from which the powder is likely to be washed into the benches.

Large numbers of these insects may be killed by the poison bait recommended for CUTWORMS (p. 107), if it is scattered along the edges of the benches where the soil comes in contact with the retaining boards.

A tanglefoot barrier may be used to keep them off unfested benches and away from seed flats.

Life History and Habits. Reproduction is accomplished by means of eggs, formed in a brown capsule that protrudes from the tip of the abdomen of the female. The capsule, which contains 25 eggs or more, is carried in this way for some time and then dropped, usually in some sheltered place, before the eggs hatch. The young resemble the adults but have no wings. They gradually increase in size, and shed their skin several times before reaching maturity. Individuals of all ages may be present at one time.

Two species are most often found in greenhouses in Illinois, the AMERICAN COCKROACH,⁶⁶ which is a dark chestnut-brown and grows to a length of 1½ inches, and the SURINAM COCKROACH,⁶⁷ which is similar in appearance but somewhat smaller. The ORIENTAL COCKROACH also occurs in Illinois.⁶⁸

Cutworms	p. 36
Earthworms	p. 54
Fuller's Rose Beetle.....	p. 63
Garden Centipede, <i>see</i> Symphylids.....	p. 96
Grasshoppers	p. 38
Grubs, <i>see</i> Strawberry Root Worm, p. 80, and White Grubs	p. 83

HAUSERMANN'S ROSE BEETLE

Larvae of HAUSERMANN'S ROSE BEETLE⁶⁹ were first observed injuring the roots of roses in a greenhouse near Melrose Park, Illinois, in 1926. They are small yellow grubs marked with orange on the back, and they grow to a length of ½ inch. They always work in the soil. When numerous, they are capable of considerable harm in the rose house, though the effect of a light infestation is hardly noticeable. They have not been known to cause serious injury except under conditions of excessive moisture in the soil. Heavy watering tends to increase their numbers.

Injury. The larvae feed on the newly formed rootlets and thus check the growth of the plants. The new shoots, if formed at all, are short and sickly. An examination of the root systems of infested plants will show a decided scarcity of roots. The adults do not feed on any part of the rose plant.

Control. When this pest becomes troublesome in the greenhouse, it is well to run the plants on the dry side. Experiments conducted in Illinois have shown that fumigating with nicotine or cyanide is not effective at dosages safe to use on plants, but that dusting the surface of every third bench with fresh pyrethrum powder, at the rate of one pound to 100 square feet of bench, is very effective against the adults.

⁶⁶ *Periplaneta americana* L.

⁶⁷ *Pycnoscelus surinamensis* L.

⁶⁸ *Blatta orientalis* L.

⁶⁹ *Philodactyla exotica* Chapin.

The pyrethrum causes the BEETLES on the treated bench to be semi-paralyzed before it kills them, and other BEETLES are attracted to them from the adjacent bench and are in turn killed by the powder.

Life History and Habits. The adult is a rather fragile, dark-brown beetle, less than $\frac{1}{4}$ inch in length. Like many other BEETLES, it is inactive during the day, but flies and crawls about after sunset, mating and laying its eggs only in the dark. The eggs are smooth and glossy-white, about $\frac{1}{75}$ inch long, and less than half as broad. They are deposited singly or in clusters of three to ten under leaves and bits of trash on the surface of the bench.

The larvae, which hatch about two weeks later, are white at first and become yellow as they mature. They are then about $\frac{1}{2}$ inch in length and have orange-colored backs. They transform to white pupae in the soil, at a depth of one to four inches, where they rest from two to three weeks before emerging as adults.

Leaf Rollers and Leaf Tyers, <i>see</i> Caterpillars...	p. 70
Midge, <i>see</i> Rose Midge.....	p. 78
Millipedes	p. 92

RED SPIDERS

RED SPIDERS, OR MITES, as they are more properly called, are often found on roses and a number of other plants grown under glass. These exceedingly minute creatures, less than $\frac{1}{64}$ inch in length, are not insects, for they have eight legs instead of only six; neither are they true SPIDERS, though they are closely related to true SPIDERS and belong to the same class, the Arachnida. They are similar to some insects in having mouth-parts that are fitted for sucking the juices out of plant tissues, but their respiratory organs are of a primitive kind ("book lungs"), so that they are not affected by insecticides and fumigants at a strength which the plants can stand with safety. It is, therefore, much more practicable to prevent an infestation of RED SPIDERS than to eradicate them after they have once established themselves in the greenhouse. They are primarily a rose pest in Illinois, although they often are found also on other crops, particularly carnation, violet, chrysanthemum, snapdragon, lantana, hydrangea, verbena, sweet pea, and lupine.

Injury. The MITES feed and build their webs on the under sides of the leaves. They pierce the leaf and extract the cell contents, causing pale-green or whitish spots, which at first show only on the under side of the leaf but later show through as the spots coalesce. The leaves so affected do not function normally and may drop prematurely. The buds also may be attacked, and even if they are not, they may still fail to produce normal flowers if the leaves are badly infested.

Infestations, if allowed to run unchecked, not only result in the plants being badly webbed but also cause them to be crippled.

Control. Since RED SPIDERS breed on a wide range of native plants and are able to withstand the winter outdoors, they are almost always present in the immediate neighborhood of a greenhouse. But since they have no wings and usually get about only by crawling, a barren strip ten feet wide or more, entirely around the greenhouse, will aid greatly in keeping them out.

In empty houses MITES can be exterminated by fumigation. Use sodium cyanide at the rate of 10 ounces to 1,000 cubic feet, or sulfur at the rate of five pounds to 1,000 cubic feet. Such heavy dosages, of course, will kill all plant life as well as most kinds of pests. (Directions for fumigation will be found on pp. 102-105.)



Fig. 28. Rose and sweet pea leaves injured by red spiders.

All incoming plants and cuttings should be given a close inspection in order to avoid the carrying in of any that are infested.

Special watch should be kept for RED SPIDERS on plants near steam pipes or other objects that radiate heat, for it is in warm dry places that infestations usually start and develop most rapidly.

RED SPIDERS can be controlled on roses and most other crops by syringing or spraying. Clear water, properly applied, is the cheapest and most effective method of control. A pressure of 75 to 100 pounds is not too great for roses when the hose is in the hands of a competent man. Moisture is detrimental to the development of the MITES, and frequent syringing washes them and their eggs off the plants into the mud, where they soon die. It also removes their webs from the leaves.

The time of syringing must be determined by the individual grower. In general, roses should not be syringed during cloudy weather, and those varieties susceptible to mildew and leaf-spot diseases require extra care, especially when the outside weather conditions prohibit proper ventilation. When the plants do not dry quickly, the water should be shaken from them by lightly tapping the stems or the support wires with a short section of hose.

Syringing alone is usually adequate to control RED SPIDERS on adiantum, asparagus, azalea, calla, gladiolus, and various other crops.

If weather conditions make syringing undesirable, infested rose plants should be sprayed every week or ten days—using one ounce of dry lime-sulfur to three gallons of water—until they start blooming. Then, if RED SPIDERS are still troublesome, "Derrisol" may be used at the rate of one fluid ounce in three gallons of water. Spraying with "Derrisol" at this strength about once a week is the preferred treatment for RED SPIDERS on acacia, achyranthes, ageratum, alternanthera, cineraria, gerbera, hydrangea, lace flower, lantana, larkspur, lupine, petunia, primrose, salvia, and schizanthus.

Spraying with some of the light oil emulsions now on the market will help to keep RED SPIDERS under control. Care must be exercised, however, in using any oil on greenhouse plants. An oil film on the leaf interferes with respiration and transpiration, so that successive applications made at short intervals or in bright sunny weather will cause roses and other plants to drop their leaves prematurely.

Life History and Habits. There are two species of these MITES generally present on roses and other crops grown under glass in Illinois. The one known as the GREENHOUSE RED SPIDER⁷⁰ is by far the most common and destructive species. It is of a general green color in its immature stages and becomes reddish-black or greenish-black as it matures. It has two characteristic black spots on the back. The EUROPEAN RED SPIDER,⁷¹ although less commonly found, is capable of inflicting very severe injury to roses and various other plants. It is slightly larger than the common red spider, and its color is always distinctly red, but it lacks the two dark spots on the back. Since both species are generally alike in life history and habits, only the common one needs to be described here.

When examined by means of a lens, the adult appears very much like a TRUE SPIDER with a compact body and short legs and with numerous hairs on the body and legs.

The eggs are laid on the webs constructed by the mites or on the surface of the leaf. The eggs are round, nearly transparent, and almost invisible, yet comparatively large for so small an animal as the red spider. Each female lays only a few eggs in a day, but in the course of four or five weeks she may produce 75 or more.

⁷⁰ *Tetranychus bimaculatus* L.

⁷¹ *Tetranychus telarius* L.

The young nymphs, which emerge from the eggs in four to twelve days, look much like the adult, though smaller. They spend eight days in the nymphal stage, feeding almost incessantly. During this growing period the females moult three times and are ready to begin laying eggs when nine or ten days old.

RED SPIDERS thrive best under warm, dry conditions and are most likely to cause severe injury in the greenhouse during cloudy weather when the plants cannot stand as much watering as at other times. They are very troublesome in the fall when steam is turned into the houses, and they continue to breed throughout the winter, attacking a very wide range of greenhouse plants.

Reinberg Bug, see Rose Midge, below.

**Root Worms, see Strawberry Root Worm, p. 80, and
White Grubs.....p. 83**

Rose Aphid, see Aphids.....p. 70

**Rose Bud Worm, Rose Leaf Roller, and Rose Leaf
Tyer, see Caterpillars.....p. 70**

ROSE MIDGE

The ROSE MIDGE,⁷² a small, white-to-orange, footless maggot that feeds inside the buds, is one of the most destructive insects with which rose growers have to deal. In the Chicago district this insect is commonly known as the REINBERG BUG, because a grower by the name of Peter Reinberg was the first in this part of the country to suffer serious losses by its work. Roses are the only plant known to be attacked, and other crops can be grown with safety in midge-infested houses. The heaviest infestation is likely to occur in the spring of the year, usually starting in March and continuing into the summer. Another period of heavy infestation comes in October or November.

Injury. Once the grower has become familiar with the injury caused by the ROSE MIDGE, he will not mistake it for the work of any other insect. The young shoots are deformed, and the infested buds may die and drop from the plant when but a few inches long or before their leaves are ready to unfold. Older buds under a lighter infestation do not show any injury until they open into deformed blossoms, and for this reason an infestation may gain considerable headway before being discovered.

Certain varieties, such as Ophelia and Columbia, are very susceptible to attack. Others, such as Killarney, are practically immune. Investigators⁷³ have listed the following varieties as hosts: Russell, Stanley, Ward, Richmond, Shawyer, Hoosier Beauty, Milady, Sunburst, Radiance, Hadley, American Beauty, Uncle John, Joe Hill, Kate Moul-

⁷² *Dasyneura rhodophaga* Coq.

⁷³ Gibson and Ross, Dom. of Canada, Dept. of Agr., Bul. No. 7; also Sasser and Borden, U. S. D. A., Bul. No. 778.

ton, Bridesmaid, Liberty, Meteor, Madam Chatenay, Ivory, Golden Gate, Wooten, La France and Duchess of Albany. While most of these varieties are no longer grown, their susceptibility may have been carried over to new varieties.

Control. The ROSE MIDGE is able to survive the winter outdoors, and the adults may enter the greenhouse by flying in during the spring and summer, or they may fly in from infested houses in the neighborhood. It is more usual, however, for this pest to be carried in, unknown to the grower, on infested plants or in infested soil attached to the roots of plants. This can be avoided only by a most careful watch.

Once an infestation is established, it is almost impossible to get complete eradication, at least with the more susceptible varieties, without

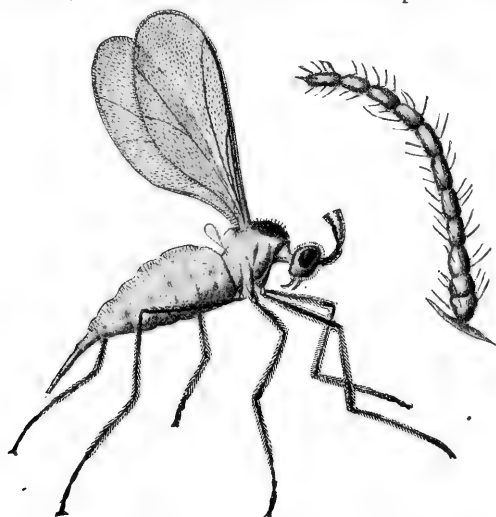


Fig. 29. Adult rose midge, greatly enlarged. The female tucks the eggs out of sight between the sepals and petals by means of the sharp ovipositor shown at the rear of the body.

first excluding roses from the greenhouse for a season. Even though complete eradication is most difficult, good roses can be grown if the following control measures are employed.

The surfaces of the benches should be kept covered with tobacco dust containing not less than 1% nicotine. First remove all leaves and trash from the benches, and have the surface of the soil fairly level; then apply the dust about $\frac{1}{4}$ inch thick, making certain that all parts of the surface are covered. The larvae dropping from the plants will be killed by contact with the tobacco dust, and the larvae and pupae

underground will be killed by the nicotine that is absorbed by the soil. Also, the walks and ground under the benches should be thoroughly and heavily sprayed with 5% kerosene emulsion (p. 109), or some similar cheap emulsion, at least once a week until the midge is under control.

This treatment has given such good control in Illinois that fumigation is seldom necessary except under unusual conditions. Very heavy infestations still may require nightly fumigations in order to reduce the numbers of the adults. However, fumigation is expensive, at best, and repeated fumigation with nicotine tends to produce woody growth in rose plants.

Infested buds, when detected, should be removed and burned.

Life History and Habits. The adult is a yellowish-brown, two-winged fly belonging to the same family of insects as the CHRYSANTHEMUM MIDGE, but is slightly smaller, being about 1/20 inch in length. The female lives only a few days and spends most of this time in egg-laying. The eggs are yellowish and very small, barely visible to the naked eye. They are laid under the edges of the sepals or between the sepals and petals, on the new growth, and between the folded leaves of the tender leaf buds. As many as 20 or 30 eggs are often laid on a single bud. The tiny white larvae, or maggots, hatch within two or three days under rose temperatures and immediately begin to burrow into the developing rose buds, leaf buds, and tender growth. After feeding for about seven days, they reach maturity and are then orange in color and less than 1/10 inch in length. Each maggot, as soon as it is through feeding, works its way out of the bud and drops to the ground, where it constructs a small white cocoon in a shallow burrow, from which it emerges as an adult in less than a week. In this way there may be two complete generations in a month, and the rate of multiplication is very high.

Slugs	p. 25
Sowbugs.....	p. 95
Spiders, see Red Spiders.....	p. 75

STRAWBERRY ROOT WORM

The STRAWBERRY ROOT WORM⁷⁴ has long been known as a serious pest of strawberries, raspberries, and other plants grown out of doors, but only in recent years has it been known to attack roses in greenhouses. It has not yet caused severe or widespread injury to roses grown under glass in Illinois as it has in other states, but it is present in many rose houses here and constitutes a menace not to be ignored by the growers. The worm itself is a small, whitish grub, less than 1/4 inch long, found in the soil among the roots. The adult is a shiny brown beetle, only 1/8 inch long, that feeds on the plant above ground. Both are capable of inflicting very severe injury, and they are most abundant and destructive during the summer months.

⁷⁴ *Paria canella* (Fab.).

Injury. The BEETLES riddle the leaves with small, more or less round holes, chew the new bark, and eat out the "eyes" of the canes, particularly after the plants have been cut back. Destruction of the new eyes, of course, ruins the future crop. The worms, or grubs, feed entirely below the ground surface, eating off the new roots and rootlets and girdling the larger roots. Sometimes as many as 20 grubs may be found in the soil around a single plant.

Control. In rose houses known to be infested, an arsenical spray should be applied immediately after the plants have been cut back. To make up this spray, dissolve three pounds of fish-oil soap or laundry soap in 50 gallons of soft water, and add four pounds of lead arsenate. Enough of the spray should be applied to the plants to give them a white-washed appearance. As the new growth appears, it should be kept covered with the 85-15 sulfur-lead dust recommended for the GREENHOUSE LEAF TYER (p. 39).

The grubs in the soil may be held in check by applying tobacco dust to the soil surface as recommended for the ROSE MIDGE (p. 78). The soil should be kept thoroughly covered from March until September.

Experiments conducted in Illinois have shown that where conditions warrant, i. e., where a heavy infestation necessitates radical measures, the grubs and pupae in the soil can be killed with a 0.5% solution of orthodichlorobenzene emulsion. (Directions for making this emulsion are given on p. 109.) The diluted emulsion should be applied at the rate of $1\frac{1}{2}$ to 2 quarts to each square foot of bench surface. Two hours after treatment the soil should be thoroughly leached with clear water. If the soil is properly leached, little if any injury to the plants will be experienced, except that with certain soils the usual effect of heavy watering may be noticed.

During the drying off period the plants may be safely fumigated with cyanide, according to Weigel and Doucette,⁷⁵ who recommend that sodium cyanide be used at the rate of $1\frac{1}{2}$ to 2 ounces to 1,000 cubic feet of space. They specify an exposure of two hours, repeated three or more times at intervals of three or four days, with final fumigation on the night before the plants are cut back. (Directions for using cyanide will be found on pp. 102-105.) It must be remembered that this dosage will injure the living growth. Conditions in Illinois do not often warrant the use of cyanide.

Life History and Habits. The adult beetles vary in color from clear black to brown with four black spots or areas on the back. When disturbed they "play possum" and are then difficult to see. During the day they remain in hiding

⁷⁵ U. S. D. A., Bul. No. 1344.

among the leaves and trash on top of the bench, coming out at night or on very cloudy days to feed. They are rather long-lived, individuals being known to survive for several months in the greenhouse. The white-to-yellowish eggs are laid in clusters of four to twelve or more on dead or dried leaves, each female laying a total of 200 or more eggs. They hatch in seven to fifteen days, and the young larvae, or grubs, enter the ground at once and proceed to feed on the rootlets. The larvae, when full-grown, are about 1/5 inch in length, fleshy, grub-like, and white in color except for the dark head and still darker mouth parts. They pupate in earthen cells within two inches of the surface of the soil and emerge 10 days later as adults. There are several broods in a year, but they overlap, so that all stages of the insect may be present at any one time.

Symphylidsp. 96

Tarnished Plant Bug.....p. 43

THRIPS

Several species of THRIPS which have been discussed in the section on chrysanthemum pests (p. 46) are also serious pests on roses. These small active insects may swarm into the greenhouse, especially in the fall of the year, and if unchecked, may ruin a large part of the crop by their attack upon the opening buds.

Injury. The leaves of rose plants are disfigured in much the same way as those of chrysanthemums, but the injury to the blossoms is more pronounced. The THRIPS show a marked preference for the unopened rosebuds, and their feeding causes the buds to break out on one side prematurely and produce crippled, unsalable blossoms. Even slightly injured buds produce flowers whose petals are streaked a darker color.

Control. The same measures recommended for THRIPS on chrysanthemums are effective on roses. However, since roses will stand more pressure, THRIPS on them may be kept down to a large extent by syringing frequently with clear water. The nymphs, or younger stages, are washed off the plants, become mixed in the mud, and are killed.

When weather conditions prohibit frequent syringing, a sweetened spray is preferred on roses. For this purpose a stock solution is easily made up by boiling together one pound of Paris green and five pounds of dark-brown sugar in two quarts of water until all the sugar is dissolved. For spraying, use 1 to 1½ quarts of this stock solution to 30 gallons of water. The spray should be applied liberally and should be directed as much as possible to the under sides of the leaves. The THRIPS are attracted to the sweetened poison and are killed. This spray has been found most effective when used after a syringing.

WHITE GRUBS

Although WHITE GRUBS,⁷⁶ or GRUBWORMS, are not of primary importance on crops grown under glass, they occasionally inflict severe losses, most often in the rose house. They are the young of "JUNE BUGS" and other BEETLES. Their distinguishing characteristics are: a large brown head, a fairly smooth, fleshy, white body curved in a semicircle when not in motion, an enlarged abdomen, and six prominent legs near the fore part of the body. When full-grown they may be as much as $1\frac{1}{2}$ inches in length. Watering often brings them to the surface. Sometimes the adult beetles fly into the greenhouse and lay their eggs in the soil on the benches, but they do not ordinarily breed indoors. Usually the eggs or young grubs are carried into the house in the soil when the benches are being filled.

The GRUBS commonly found in manure should not be mistaken for these ROOT-EATING WHITE GRUBS. Those species found in manure do not attack living plants but feed only on decaying organic matter.

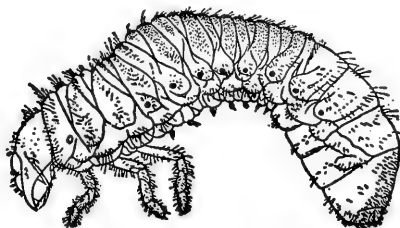


Fig. 30. White grub.

Injury. WHITE GRUBS feed on the roots and rootlets of roses and many other plants, thus weakening the plants and causing the new growth to wilt during the day. Under a severe attack young plants are killed.

Control. If soil that is known to contain WHITE GRUBS must be used in the greenhouse, it should be sterilized with steam (p. 91) or treated with carbon bisulfide (p. 106) after the benches are filled.

If soil has been planted up before the GRUBS are discovered, their numbers may be considerably reduced by having someone follow the watering hose and pick up the GRUBS as they come to the surface.

One method of preventing infestations is based on the fact that these pests have a life cycle covering three years. There are some grubs every year, but their numbers are greatest each third year. This

⁷⁶ Larvae of various species belonging to the family SCARABAEIDAE, chiefly of the genus *Phyllophaga*.

means that, over the greater part of Illinois, ground that is in grass sod or a small grain crop in 1929, 1932, 1935, and so on at intervals of three years, will be much more likely to contain WHITE GRUBS than ground that is in clover or alfalfa or that is under clean cultivation during those years. In fact, the use of clover or alfalfa as a green manure or cover crop for greenhouse soils, together with clean cultivation when no crop is grown, will reduce the possibility of WHITE GRUB injury to a minimum.

Life History and Habits. There are many species of WHITE GRUBS, differing little in general appearance, either as larvae or adult beetles, and most of them probably have a life cycle that covers three years. A knowledge of their way of life may aid the grower in detecting their presence in time to avoid serious losses. The adult "JUNE BUGS," which are so well known that a description is hardly necessary, emerge from the ground in May and June, feeding during the day on the leaves of trees and laying their eggs at night in the soil, usually in sod land. They are attracted to lights at night. The eggs, which are white, oval, and about 1/10 inch long, are laid in a small compact ball of earth, from one to five inches below the soil surface, so that they are very difficult to detect. The larvae, or grubs, hatch in about two weeks, most of them hatching in Illinois before the middle of July. They remain in the ground for three years.

SALVIA PESTS

Aphids, or Plant Lice	p. 89
Red Spiders	p. 75
Whiteflies	p. 16

SANSEVIERIA PESTS

Red Spiders	p. 75
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SCHIZANTHUS PESTS

Red Spiders	p. 75
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SMILAX PESTS

The major pests of smilax are the GARDEN FLEAHOPPER, RED SPIDERS, SYMPHYLIDS, THRIPS, and WHITEFLIES. The CABBAGE LOOPER, EELWORMS, MILLIPEDES, SOWBUGS, and several species of CUTWORMS are occasionally troublesome. The GARDEN FLEAHOPPER is the only pest described here with special reference to its work on smilax and the measures to be used for its control. The other pests are listed below in alphabetical order, with cross-references to pages where they are discussed under other crops.

Cabbage Looper	p. 22
Centipedes, <i>see</i> Symphylids.....	p. 96
Cutworms	p. 36
Eelworms	p. 90

GARDEN FLEAHOPPER

Smilax, carnations, daisies, lupines, and primroses are very susceptible to injury by the GARDEN FLEAHOPPER,⁷⁷ a small, dark, active bug sometimes mistaken for a BLACK APHID. This pest is not a continual nuisance to the florist as the aphids are, but occurs sporadically, and it is likely to be most troublesome in greenhouses near truck-gardens or weedy fields, where it thrives best. Though it can breed in the greenhouse throughout the year, it is usually a spring or fall pest.

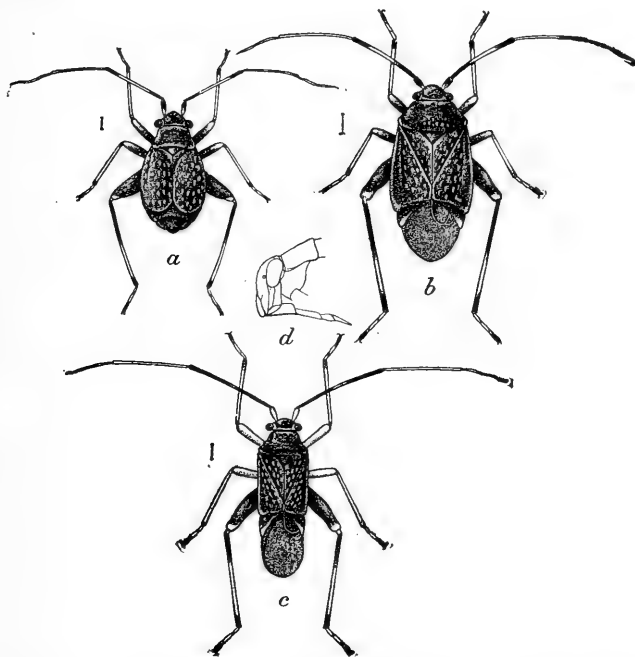


Fig. 31. Garden fleahoppers—(a) nymph, (b) short-winged adult and (c) long-winged adult. Often mistaken for "blackflies."

Injury. Like other true bugs, the GARDEN FLEAHOPPER feeds by puncturing the surface of the leaf and sucking out the cell contents. Leaves that have been fed upon appear blotchy and may die.

Control. GARDEN FLEAHOPPERS infesting smilax can be controlled by spraying with nicotine and soap, using one ounce of 40% nicotine sulfate and one ounce of fish-oil soap or laundry soap in five gallons of water. The insects must be hit with the spray if they are to be

⁷⁷ *Halticus citri* Ashm.

killed. While smilax is very susceptible to injury by cyanide fumigation, the more hardy host plants can be fumigated with calcium cyanide and the insects thus held in check.

Life History and Habits. Some adults of this species are long-winged and others are short-winged. The former have long, narrow bodies, while the latter appear slightly shorter and more robust. Both forms have rather long legs and very long antennae. The female in the long-winged form looks much like the TARNISHED PLANT BUG (p. 43), though very much smaller. The short-winged form and the young nymphs look much like BLACK APHIDS, but may be readily distinguished by their habit of jumping a considerable distance when disturbed.

The adults normally live over winter in weeds and trash outdoors and fly into the greenhouse through open doors and ventilators in the spring. Their heaviest invasions, however, sometimes occur in the fall.

The eggs are laid in the leaf of the host plant and hatch after about 10 days into greenish, wingless nymphs. The nymphs mature in three to four weeks and are then black in color and about 1/10 inch long.

Millipedes	p. 92
Red Spiders	p. 75
Sowbugs	p. 95
Thrips	p. 46

Whiteflies (p. 16), when infesting smilax, are best controlled by spraying with nicotine sulfate or nicotine oleate as recommended for the control of MEALYBUGS (p. 50).

SNAPDRAGON PESTS

Snapdragons are very susceptible to insect attack. BEES, especially the HONEY BEE, are often serious pests in the spring of the year. APHIDS, CUTWORMS, the CYCLAMEN MITE, the GREENHOUSE LEAF TYER, RED SPIDERS, SLUGS, the TARNISHED PLANT BUG, THRIPS, and WHITEFLIES are all capable of inflicting severe damage. These pests and four others sometimes attacking snapdragons are listed below with cross-references to discussions of them under crops on which they are more often found.

Aphids (p. 89) on snapdragons are known to most growers as "GREENFLIES." Since snapdragons are quite susceptible to burning by hydrocyanic acid gas, fumigation with any form of cyanide should be used with great care or not at all.

BEES

Snapdragons are frequently damaged by BEES, the chief offender being the HONEY BEE.⁷⁸ Snapdragons bloom from the base of the flower stalk toward the tip, those toward the base of the stalk opening

⁷⁸ *Apis mellifera* L.

first, and before the stalks can be best cut for market the flowers should be well out toward the tip. By this time the lower flowers are well developed and are very susceptible to injury by bees.

Injury. The corolla of the snapdragon is so constructed that the BEES are unable to get at the nectar and pollen without wedging themselves in so far that they break down the walls of the corolla. Blossoms entered by the BEES soon wilt and usually die prematurely, thus spoiling the attractiveness of the stalk and often making it necessary to strip off the lower blossoms before selling.

Control. The only satisfactory control known consists of screening the doors and ventilators.

Cutworms	p. 36
Cyclamen Mite (p. 52) on snapdragons can be controlled by the measures given on p. 62.	
Greenhouse Leaf Tyer.....	p. 39
Greenhouse Orthezia	p. 50
Mealybugs	p. 50
Red Spiders	p. 75
Slugs	p. 25
Tarnished Plant Bug.....	p. 43
Thrips.....	p. 46
Whiteflies	p. 16
White Grubs.....	p. 83
Wireworms	p. 27

SOLANUM PESTS, *see* CHERRY PESTS, p. 28.

SPIRAEA PESTS

Aphids, or Plant Lice.....	p. 89
Red Spiders	p. 75
Thrips.....	p. 46

CAUTION: Spiraea is extremely sensitive to fumigants.

STEVIA PESTS

Aphids, or Plant Lice.....	p. 89
Whiteflies	p. 16

STOCK PESTS, *see* SWEET ALYSSUM PESTS, *below*.

SWEET ALYSSUM, STOCK and WALLFLOWER PESTS

These crucifers are but moderately susceptible to insect attack. The DIAMOND-BACK MOTH is a frequent pest and may spoil the appearance of their foliage in a short time. The seven other pests listed below can be controlled by the same measures as are recommended in connection with the crop under which each pest is discussed elsewhere in this manual.

Aphids, or Plant Lice.....	p. 89
Cutworms	p. 36

DIAMOND-BACK MOTH

Sweet alyssum, stocks, wallflowers, candytuft, lunaria, and other *Cruciferae* are sometimes attacked by the DIAMOND-BACK MOTH,⁷⁹ especially where greenhouses are in close proximity to fields of cabbage, cauliflower, horse-radish, radish, turnip, rape, kale, or wild mustard—on all of which the insect breeds.

Injury. The caterpillars of the DIAMOND-BACK MOTH eat small holes in the under side of the leaves. The upper surface soon dies and the brown areas fall out, so that the leaves are riddled with holes.

Control. Cabbage fields and fields of related crops near the greenhouse should be plowed as soon as the crop is harvested. Infested plants in the greenhouse should be dusted with the following mixture, using care to dust the under sides of the leaves.

Dusting sulfur (300 mesh).....2 pounds
 Arsenate of lead.....1 pound

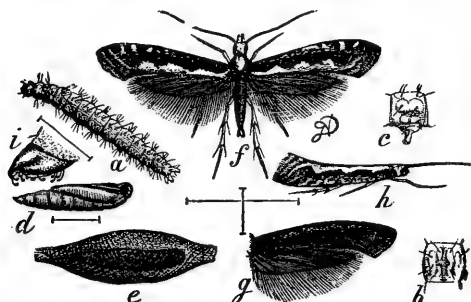


Fig. 32. Diamond-back moth. Likely to be most troublesome in greenhouses near fields where vegetables are grown.

It is well to watch for this pest after the first few cold days in the fall and to fumigate with nicotine (p. 105) or with calcium cyanide (p. 102) as soon as the moths are discovered.

Life History and Habits. The adult is a gray moth with a wing expanse of about $\frac{3}{5}$ inch. The fore wings of the male are gray, thickly covered with black spots, and have an irregular, yellowish stripe along the hind margin. When at rest the wings are folded so that the yellowish stripes unite to form diamond-shaped markings down the middle of the back. The wings of the female are almost uniformly gray.

The eggs are whitish or yellowish and very minute, only $\frac{1}{25}$ inch in diameter, and are laid singly or in small clusters on the leaves. They hatch in four to six

⁷⁹ *Plutella maculipennis* Curtis.

days into small, active caterpillars, which immediately begin to feed on the leaf tissues. The caterpillars become full-grown in about four weeks and are then about $\frac{1}{2}$ inch in length, light-green in color, and sparsely covered with short black hairs. If disturbed, they wriggle off the leaf and hang suspended by a silken thread. When mature each one spins a beautiful, net-like cocoon which is fastened to the under side of the leaf and which is so frail and delicate that the pupa within it can easily be seen. The adult emerges in 4 to 14 days. This insect breeds continuously in the greenhouse.

Red Spiders	p. 75
Slugs	p. 25
Tarnished Plant Bug	p. 43
Thrips	p. 46
Wireworms	p. 27

SWEET PEA PESTS

Sweet peas with their delicate, tender growth are very susceptible to insect attack. Any pest with a liking for them is capable of severely injuring the crop and, in short, is likely to prove of major importance. No other greenhouse crop is subject to attack at the roots by a larger number of pests, partly because sweet peas have an unusually fine root system and partly because a large part of this crop is grown in solid beds where the eradication of soil pests is most difficult. EELWORMS, ROOT APHIDS, FUNGUS GNATS, and SYMPHYLIDS attack the root system exclusively; while CUTWORMS, MILLIPEDES, and SOWBUGS attack the stems near the ground as well as the roots. Of the pests feeding on the foliage, the RED SPIDERS are most troublesome. Other insects which sometimes attack sweet peas, inflicting severe injury, are named in the following list, each with a reference to the pages where the reader will find it discussed in connection with a crop on which it is more often found.

APHIDS, OR PLANT LICE

Sweet peas and many other greenhouse plants are often stunted, and more or less covered with sticky honeydew, by "GREENFLIES" and various other kinds of APHIDS having much the same shape but ranging in color from green through reddish-brown to black. While the APHIDS described under chrysanthemum pests (p. 29) and rose pests (p. 70) are limited to those crops, there are many species⁸⁰ that are general feeders, some of which attack almost every crop that is grown under glass.

⁸⁰ The green peach aphid, *Myzus persicae* (Sulz.); the pea aphid *Illinoia pisi* (Kalt.); the potato aphid, *Illinoia solanifolii* (Ashm.); the lily aphid, *Myzus circumflexa* (Buckton); the melon aphid, *Aphis gossypii* Glover; and others.

Injury. These PLANT LICE, as they are often called, cause the leaves and terminal growth to be deformed and the flowers to be dwarfed and soft. Some of them are a further nuisance because they give off a sticky liquid that promotes the growth of sooty fungi, making the plants unsightly. Aphids are also the carriers of certain diseases which often cause heavy losses, especially on sweet peas.

Control. Most of the control methods given on p. 29 can be used on all crops, but cyanide fumigation of sweet peas is very dangerous. If any form of cyanide is used at all on this crop, the greatest care must be taken, or the plants will be killed as well as the pests.

See also ROOT APHIDS, p. 94.

Centipedes, <i>see</i> Symphylids.....	p. 96
Cutworms	p. 36

EELWORMS OR NEMATODES

If sweet pea vines stop growing and begin to wilt, or if their leaves die prematurely, a few vines should be dug up and an examination made for swollen, knotty roots, which are evidence of attack by EELWORMS.⁸¹

Injury. On sweet peas the characteristic galls or knots are formed on the roots relatively near the surface. These knots should not be confused with the nodules formed on the roots of sweet peas by nitrogen bacteria. The latter are *attached* to the root while the knots formed by EELWORMS are a part of the root itself. On cyclamen, rose, carnation, chrysanthemum, passion vine, violet, geranium, lettuce, cucumber, tomato, and some other crops the galls are formed on all parts of the root system. The distorted, hairy growth occurring at the base of otherwise healthy sweet pea vines has never been found by the writer except in the presence of EELWORMS or MITES or both.

The EELWORMS, upon burrowing directly into the plant root, set up some sort of irritation which causes the root to swell at that point. Infested roots do not function properly in carrying water and food to the plant, with the result that it becomes stunted and deformed. They thrive best in moist, sandy soils where the soil temperature ranges between 50° and 75°F.

Control. There is no known corrective measure that will save plants already infested. The only safe method to use in the control of EELWORMS in ground beds is steam sterilization. Raised benches

⁸¹ *Heterodera radicola* Mull. and others.

should be emptied, cleaned thoroughly, and filled with new soil. Hot lime should be applied to the empty benches and allowed to dry for a few days before filling. Great care should be exercised to obtain soil free from EELWORMS when a change is made. Steam sterilization loses its value if care is not used to prevent recontamination.

STEAM STERILIZATION

Tile Method. If the greenhouse is tiled for drainage, the same tile may be used for sterilizing the soil, providing the lines are laid about 14 inches deep and not over 30 inches apart in parallel. To serve this purpose, lines of tile should be laid near the walls and walks, so that the steam will reach the isolated parts of the house, and the opposite ends must be connected by cross-heads, so that the steam can pass from one line to the next. Experience and boiler capacity will determine the area that may be treated at one time. As a general rule a boiler will handle about 1/10 the area it is capable of heating. In order that sterilization may be effective, however, it is necessary to treat entire units to a depth of 18 to 24 inches simultaneously. The steam is turned into the tile lines at a pressure of 10 to 25 pounds and allowed to run about four hours. The process is not complete unless medium-sized potatoes placed in the soil a few inches below the surface are well cooked. This is the usual test of proper steaming.

Pipe Method. This method is adapted to raised benches and may be used for ground beds if care is taken not to contaminate the sterilized areas again by walking over them from the untreated areas or otherwise introducing new contamination. Lines of 1½ or 2-inch pipe, perforated with ⅜ or ¼-inch holes at intervals of one foot, are buried in the soil at a depth of about 12 inches and at a distance of 14 to 16 inches from each other, and the steam is turned into these lines as in the tile method. The removal of the pipes is most easily accomplished by means of wires placed around them at intervals of 15 to 20 feet when they are buried, the ends of the wires being allowed to extend above the soil surface, so that the pipes may be easily raised without digging after the steaming process. While one section is being steamed, trenches may be dug in the next section and the pipes shifted with very little loss of time. The perforations in the pipes should be on the under side, so that the steam is directed downward into the beds.

In both the tile method and the pipe method, the sterilization process can be hastened by covering the soil with burlap, canvas, or boards. The shorter the time required for sterilizing, the less likelihood there is of producing a soggy condition in the soil.

Pan Method. The "pan" method is best adapted to sterilizing raised benches and flats of soil. The area to be sterilized at one operation is covered with a shallow galvanized-iron pan, the width of the bench and 10 to 15 feet in length. This inverted pan is fitted tightly

to the ground and the steam turned into it for a period of 30 to 40 minutes. A low pressure (5 to 20 pounds) of steam on the boiler is sufficient for this work, since the pan over the bench would not hold any great pressure.

If the sides of the pan are made 6 to 8 inches in depth, it may be used to sterilize soil in flats as well as in benches. The flats filled with soil are placed on a bench or on a cement floor and separated by strips of lath; the pan is then inverted over them and the steam turned in. This method sterilizes the flats, as well as the soil. Besides killing insects and other animal pests, it destroys the organisms that cause diseases, such as "damping off" diseases, and also kills weed seeds.

Flower pots or a small amount of soil may be sterilized in a tight barrel. The steam is run into the center of the barrel by means of a U-shaped pipe having $\frac{1}{8}$ -inch perforations at intervals of 4 to 6 inches. The perforations in this pipe should be made on all sides instead of in a straight line on one side.

Fungus Gnats	p. 57
Greenhouse Leaf Tyer.....	p. 39

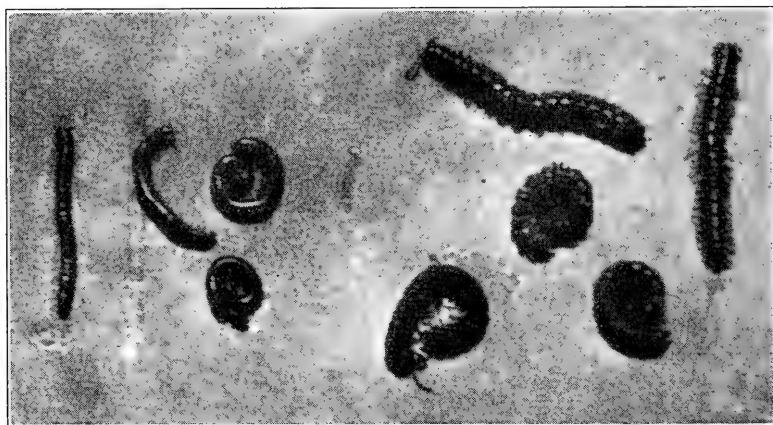


Fig. 33. Two species of millipedes: *Diploinus luscus* Meinert, on the left; and *Orthomorpha gracilis* (Koch), on the right.

MILLIPEDES

MILLIPEDES are brown, slow-moving, many-legged "creepers" often called "thousand-legged worms." They are usually found coiled up in the soil, under lumps of manure or other objects. They should not be mistaken for SYMPHYLIDS, or CENTIPEDES, which have much longer legs, move very rapidly when disturbed, and do not coil themselves.

Two species of MILLIPEDES are commonly found in Illinois greenhouses, often in large numbers where quantities of manure are used. The larger, darker-brown species⁸² is harmful because it feeds on living plant tissue; while the smaller, lighter-brown species⁸³ feeds on decaying vegetable matter and is harmless to living plants. The injurious kind is marked with pronounced light-colored bands, and its body is flattened and distinctly segmented. The body of the harmless species is cylindrical and not so distinctly segmented. MILLIPEDES ordinarily do not attack any greenhouse plant as long as they can find plenty of moist manure on which to feed.

Injury. The DARK-BROWN MILLIPEDE feeds on the stems and roots of sweet peas, often completely girdling the stems and finally killing the plants. It has been observed feeding on coleus, geranium, and other fleshy-stemmed plants, boring upward in the stems for several inches above ground. Tests carried on in Illinois have shown that this species of MILLIPEDE will feed on the roots of roses and other plants when moist manure or other decaying vegetable matter is not available. Young seedling of various kinds are often attacked and killed. Since these pests are active only at night, they may become very numerous before they are observed.

Control. MILLIPEDES may be controlled by using the poison baits described on p. 107. The bran bait with two extra quarts of molasses added to it is particularly attractive to these pests. Tobacco dust or fresh pyrethrum powders are also effective.

Where MILLIPEDES are so abundant as to make baits useless, heavy dusting with tobacco powder *after watering* is effective.

Life History and Habits. MILLIPEDES reproduce by means of tiny white eggs—less than 1/50 inch in diameter—which they lay in dense clusters in the soil, or under lumps of manure, or on the surface of the soil if it is moist enough. The eggs of the injurious species are quite round, while those of the harmless species are distinctly oval.

CENTIPEDES can be distinguished from MILLIPEDES by their grayish-white color, their smaller number of legs, and their habit of running rapidly over the soil. A very common species of CENTIPEDE, mentioned as a predator in Part One (p. 13), feeds on the eggs and younger forms of many soil-inhabiting pests and is known to have aided in holding injurious MILLIPEDES in check in Illinois greenhouses.

Nematodes, <i>see</i> Eelworms.....	p. 90
Red Spiders	p. 75

⁸² *Orthomorpha gracilis* (Koch).

⁸³ *Diploitus luscus* Meinert.

ROOT APHIDS AND ANTS

Sweet pea and aster roots are attacked by two species of LICE, or APHIDS, the PINK ROOT APHID,⁸⁴ which is particularly injurious to sweet peas, and the CORN ROOT APHID,⁸⁵ which is more often destructive to asters. These little ROOT LICE are unable to travel far except in their winged form, but they are carried from plant to plant by ANTS, usually the CORN FIELD ANT,⁸⁶

Injury. The feeding of APHIDS on the roots stunts the growth of the plants, causes them to wilt during the day, so that their leaves die prematurely, and finally kills the entire plants. The evidence of injury by these pests is similar to the effects of infestations by EELWORMS, or NEMATODES (p. 90), and SYMPHYLIDS, or GARDEN CENTIPEDES (p. 96).

Control. APHIDS feeding on the roots of plants may be checked by watering the plants with nicotine solution, using one ounce of 40% nicotine sulfate to four gallons of water. Nicotine dust worked into the soil will also give some relief.

The most important procedure, however, is to exclude or destroy the ANTS which are largely responsible for disseminating the APHIDS. During the summer it sometimes is difficult to keep ANTS from coming into the greenhouse, but they can be successfully eradicated before the main crop of sweet peas is planted. The plowing of a 10-foot strip entirely around the greenhouse is recommended, where this is at all practicable. To be effective, the plowing must be at least seven inches deep, and it should be followed by two or three thorough diskings at weekly intervals.

ANT nests occurring too close to the outside walls to be reached by plowing, as well as those occurring within the greenhouse, should be located and destroyed. This is quite easily done by following the workers back to the nests, making several 1-inch holes about one foot deep in the ground around each nest, and pouring one tablespoonful of carbon bisulfide or one teaspoonful of granulated calcium cyanide into each hole. The holes should be plugged with moist earth after treatment. Both the bisulfide and the cyanide should be used with special care in the greenhouse, for the fumes are injurious to plant roots. Fortunately, ANTS almost never make their nests in the benches, and it is very easy to destroy a nest there by simply removing the infested portion of soil.

⁸⁴ *Tulgrenea phaseoli* Passerini.

⁸⁵ *Anuraphis maidi-radidis* (Forbes).

⁸⁶ *Lasius niger americanus* Emery.

Sometimes it will be found desirable to use a poison bait for ANTS. The following formula is recommended:

Sugar	1 pound
Water	1 pint
Arsenate of soda.....	$\frac{1}{4}$ ounce
Honey	1 tablespoonful

Put the sugar and the arsenate of soda in the water, and boil until the poison is completely dissolved, and then add the honey. Small pieces of sponge or strands of excelsior should be well soaked in this syrup and placed in small tin boxes, the lids of which have been punched with several holes, so that the ANTS will have ready access to the bait. These boxes should be distributed in the greenhouse wherever the ANTS are numerous.

Life History and Habits. Adult ROOT APHIDS do not live over winter outdoors, but the eggs are collected in the fall by the ANTS and stored in their nests until early spring, when the young APHIDS hatch out and are carried by the ANTS to the roots of suitable plants. They suck the sap from the roots and become full-grown in two or three weeks. Then they begin giving birth to living young, all of which are females, and these in turn grow to maturity within two weeks and produce more young, so that the numbers of these pests multiply rapidly for several months. In August some of the young become males, and others become winged females. After mating, the latter sometimes crawl to the surface of the soil and fly away to lay their shiny dark-green eggs elsewhere, thus establishing new colonies. Most of the eggs, however, are laid in the ground near the host plants, where they are gathered by the ANTS and stored for the winter. The honeydew exuded by the APHIDS forms a large part of the food of the ANTS.

SOWBUGS AND PILLBUGS

Sweet peas and numerous other plants are attacked by SOWBUGS or PILLBUGS,⁸⁷ grayish, fat-bodied, slow-moving creatures, up to $\frac{1}{2}$ inch in length, which may be found at work on the stems near the ground or under bits of manure on the surface of the bench.

Injury. These pests feed on the roots and tender stems of many kinds of plants and are capable of inflicting very severe injury to greenhouse crops. They are particularly fond of young seedlings and cuttings and the roots of orchids and other tender plants. They are especially injurious to sweet pea vines because of their habit of chewing and girdling the stems near the ground. Plants thus attacked begin to whiten and die at the tips. The injury is very similar to that caused by DARK-BROWN MILLIPEDES (p. 93).

⁸⁷ *Armadillidium vulgare* (Latrielle), *Porcellio laevis* Koch, and others.

Control. SOWBUGS and PILLBUGS are easily kept under control unless they are allowed to become established in large numbers. They are attracted to sweetened baits and also to baits containing much starch. An effective bait may be made by mixing one part of Paris green with nine parts of powdered or granulated sugar. This mixture should be sprinkled lightly along the edges of the benches and walks, but it is not recommended for application to the soil on benches, since roses and some other greenhouse plants are injured by the Paris green. When the pests seem to avoid this bait a change to wheat shorts or middlings in place of the sugar will be found advantageous. They will often feed readily on the poison bran bait described on page 107, but when this is used for the control of sowbugs the amount of molasses should be doubled and the mixture should be made rather sloppy.

SOWBUGS and PILLBUGS may be kept off seed flats by a tanglefoot barrier, and they may be trapped under boards, etc., laid flat on the ground. Because of their fondness for seeking out protected places, control will be greatly facilitated if no trash is allowed to accumulate under the benches, and if no flats are stored there. Fresh pyrethrum powder is very deadly to sowbugs, and proprietary compounds containing this poison are often used.

Life History and Habits. These pests are not insects but belong to the class of Arthropods called Crustaceans, which include crayfish, lobsters, and crabs. They have seven pairs of legs but use only five pairs in walking. They reproduce by means of eggs, which are kept in the "pouch" of the female for about two months before they hatch. The young, after leaving the "pouch," require a year to become full-grown, and they live on for a long time. Individuals of all ages may be found together in the greenhouse.

SYMPHYLIDS

If young sweet pea vines or various other plants stop growing and begin to wilt, or if their lower leaves drop prematurely, a search should be made among their roots for small, whitish, many-legged, swift-running creatures called SYMPHYLIDS or CENTIPEDES. (Also see EELWORMS, p. 90.)

The kind of SYMPHYLIDS known as the GARDEN CENTIPEDE⁸⁸ has increased alarmingly in abundance and destructiveness in Illinois within the last few years. In fact, this pest now threatens to force the abandonment of solid beds in the growing of flowers under glass. The earliest recorded cases of SYMPHYLID injury to any greenhouse crop in Illinois were reported by Davis (1912) as occurring in 1908 on fern, asparagus, and smilax. In the past three years the writer has observed SYMPHYLIDS feeding on sweet pea, aster, rose, chrysanthemum, gladi-

⁸⁸ *Scutigera immaculata* (Newport).

olus, asparagus, ferns, coleus, Easter lily, smilax, lettuce, cucumber, tomato, wild mustard, thistle, pigweed, and other weeds occasionally found in the greenhouse. In fact, no plants are known to be immune.

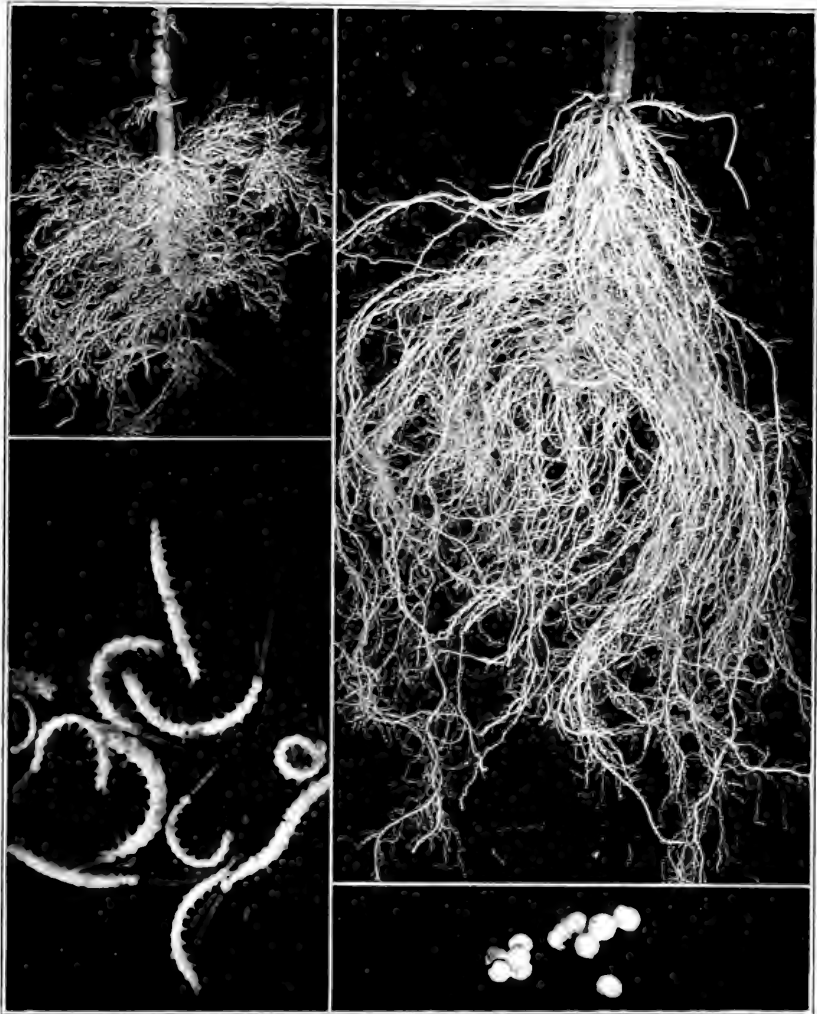


Fig. 34. Symphylids (lower left), their eggs (lower right), and the effect of their work on a root system (upper left) compared with a normal root system (right). A young symphylid can be seen emerging from one of the eggs.

In Cook County chrysanthemums and tomatoes in raised benches recently were found to be severely injured, and the SYMPHYLIDS were breeding there in large numbers.

These fragile creatures are found in the soil to a depth of three feet or more, depending on the type of soil and subsoil, moisture, and other conditions. They are never found above ground in the light, and if brought to the surface they get back into the soil as quickly as possible. They are unable to make their own way in the soil, except where much humus affords natural cavities, but usually follow the channels left by decaying roots or by earthworms and other soil-inhabiting animals. The practice of placing a layer of cinders in the bottom of ground beds, to allow for drainage, affords ideal conditions for SYMPHYLIDS to work. Delicate as they are, they are not easily drowned, but can survive for 24 hours or longer completely submerged in water.

In looking for these pests, dig into the soil about the plant roots. The best time to do this is shortly after watering, for they are then near the surface. Where the ground is dry they may be found much deeper in the soil.

Injury. SYMPHYLIDS, or GARDEN CENTIPEDES, feed on the tender new roots and, when numerous, will eat off the new growth as fast as it is formed. Plants with roots heavily infested with them become stunted and deformed. When sweet peas and other crops are only mildly attacked, no greater injury may be visible than the failure of the plants to make normal growth. These pests also tunnel into the larger roots and the underground portion of the stem, causing small, wart-like growths where organisms of disease and decay readily enter. Some of these warty growths, as well as the stunted root system, are shown in the photograph on page 97.

Control. The control of SYMPHYLIDS is difficult because they live and reproduce entirely under ground. Since they are well able to survive the winter outdoors, care should be taken not to bring them into the greenhouse in the spring or summer with new soil or rotted manure. Every precaution should be taken, also, not to bring them in on shipments of plants with soil attached to the roots.

The most effective permanent control is obtained by raising the benches and supplying clean soil. This is as economical as any known treatment when control over a period of years is considered. It also has the advantage that the benches in one part of the house can be raised at a time without danger of reinfestation from the other parts. Since, however, there are certain distinct advantages in ground beds where certain crops are grown, many greenhouse men will prefer not to use benches exclusively but to do everything possible to keep these pests out of their greenhouses altogether.

Steam sterilization will kill all the SYMPHYLIDS in the upper part of the soil, but in the case of ground beds the sterilization must include the walks in order to be effective. Even then, some SYMPHYLIDS and their eggs in the subsoil will survive, necessitating yearly treatments with steam if they are to be kept under control. (Directions for steam sterilization are given on p. 91.)

A large number of chemicals have been tried in Illinois, but none of the treatments so far devised are satisfactory under the conditions maintained in greenhouses devoted to the production of sweet peas and other flowers.

Life History and Habits. A full-grown SYMPHYLID measures scarcely $\frac{1}{4}$ inch in length and is very slender. The younger stages look much like the adults, though smaller. There is a pair of legs for almost every segment of the body. The general color is white, but the darker food in the body cavity is visible through the back. The head is distinct from the body and has two long, many-jointed antennae. SYMPHYLIDS have no eyes, but feel their way along their silk-lined runways by means of their antennae.

The eggs are laid in small cavities in the soil and subsoil, in clusters of 3 to 15, usually from 9 to 12 being in a cluster. They are barely visible to the naked eye, but under the microscope are seen to be peculiarly marked with short, stiff, hair-like projections, which are connected at their tips with silk-like material serving to hold them together. Most of the eggs are laid 12 to 16 inches below the soil surface. In the greenhouse they are to be found at all times of the year. During December and January reproduction is at low ebb, and it increases during the late winter and spring months to the maximum rate during the summer. The eggs hatch in 8 to 21 days, the exact time required depending largely upon the soil temperature. Specimens have been reared by the writer from the egg through the last molt in an average of 40 days and, in one case, in as short a time as 32 days.

TELANTHERA PESTS, *see* ALTERNANTHERA PESTS, p. 18.

TULIP PESTS, *see* BULB PESTS, p. 19.

UMBRELLA PLANT PESTS

Mealybugs	p. 50
Red Spiders	p. 75

VERBENA PESTS

Greenhouse Leaf Tyer.....	p. 39
Red Spiders	p. 75
Thrips.....	p. 46
Whiteflies	p. 16

VINCA PESTS

Scale Insects	p. 59
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VIOLET (and PANSY) PESTS

Pansies and violets are subject to attack by thirteen different pests, any of which are capable of inflicting serious damage. The APHIDS, CUTWORMS, EELWORMS, GREENHOUSE LEAF TYER, MILLIPEDES, RED SPIDERS, SLUGS, and SOWBUGS are most frequently encountered. The GREENHOUSE ORTHEZIA, MEALYBUGS, WHITEFLIES, and WIREWORMS also sometimes attack these crops.

APHIDS

Violets and pansies are frequently infested with "GREENFLIES," of which the GREEN PEACH APHID⁸⁹ is an example, and with a "BLACK-FLY," the VIOLET APHID.⁹⁰ The injury on these crops is similar to that caused by APHIDS on other plants (p. 29), but certain special precautions should be used in applying control measures.

Control. Nicotine, whether applied as a spray, dust, or fumigant, is likely to injure the foliage, causing it to become spotted. For this reason it is well to avoid nicotine altogether. Calcium cyanide may be used with safety at the rate of $\frac{1}{8}$ ounce to 1,000 cubic feet of greenhouse space. Sprays are preferred, however, and several have been found effective, including "Derrisol" (one ounce to four or five gallons of water), "Evergreen," and other similar preparations, all of which should be used as directed by the manufacturers.

Blackflies, *see* Aphids *above*.

Cutwormsp. 36

Eelwormsp. 90

Greenhouse Leaf Tyer.....p. 39

Greenhouse Ortheziap. 50

Mealybugsp. 50

Millipedesp. 92

Red Spiders (p. 75) on violets are best controlled by means of a lime-sulfur spray. Use one ounce of dry lime-sulfur to four gallons of water, and syringe thoroughly four hours after spraying. The plants should then be run as wet as the condition of the crop will allow, since moisture is detrimental to the mites.

Sawfly, *see* Violet Sawfly *below*.

Slugsp. 25

Sowbugs.....p. 95

⁸⁹ *Myzus persicae* (Sulz.).

⁹⁰ *Neotoxoptera violae* (Perg.).

VIOLET SAWFLY

The VIOLET SAWFLY,⁹¹ common on violets and pansies grown outdoors, occasionally enters the greenhouse and feeds on these crops. The adult is a black, bee-like insect with four wings which lie flat over its back when it is at rest. The larva is a small caterpillar which has the peculiar habit of bending the fore part of the body back in "J" shape when at rest. This habit will help to distinguish it from the CUTWORMS, and its dark gray color will help to distinguish it from the GREENHOUSE LEAF TYER. Illinois growers who formerly had considerable trouble with this pest report that they have rarely seen it in the greenhouse in recent years.

Injury. When the larvae are small they eat off the tissues on the under side of the leaf, causing injury similar to that of the GREENHOUSE LEAF TYER and SLUGS. As they mature they eat small holes in the leaves or eat away sections along the edges, causing injury similar to that done by CUTWORMS. The adults also do harm by inserting their eggs in the leaf tissue, causing the leaf to wilt and die.

Control. The VIOLET SAWFLY is successfully controlled by means of the same dust as is recommended for the control of the GREENHOUSE LEAF TYER (p. 39). Care should be used to blow the dust into the plants from all sides in order to coat the under surface of each leaf.

Life History and Habits. The female SAWFLY lays her eggs in the upper tissues of the leaf. They may be located by examining the under side of the leaf, where slightly raised, blister-like areas will be seen. The full-grown larva is about ½ inch long, dark-gray, and marked with many slightly raised white spots on the back and sides. The larvae hide during the day just under the soil surface, under the leaves, or along the stems near the ground. When mature they seek out decaying wood or the stems of pithy plants in which to pupate.

White Grubs.....p. 83

Wirewormsp. 27

WALLFLOWER PESTS, *see* SWEET ALYSSUM PESTS, p. 87.

ZANTEDESCHIA PESTS, *see* CALIA PESTS, p. 22.

⁹¹ *Allantus canadensis* (Kirby).

PART THREE

FUMIGANTS, INSECTICIDES, AND APPLIANCES

FUMIGANTS

Since dosages for greenhouse fumigation are expressed customarily in terms of 1,000 cubic feet, the first requirement is to determine accurately the cubical contents of the house. This is done by computing the number of square feet in the end-wall and multiplying this number by the length of the house in feet. It is then a simple matter to determine the amount of fumigant material to use for any desired dosage. Dry materials should be weighed, not measured by volume. After the proper amount of material to use in a particular house has been determined, it may be marked on the side of the container and measured for subsequent fumigations.

Before starting to fumigate, make sure the ventilators and doors are tightly closed. Broken glass should be replaced or the openings covered with paper.

Cyanide Fumigation. The efficiency of hydrocyanic acid gas in the control of certain greenhouse insects has long been known. This deadly gas is derived from the cyanides of sodium, potassium, and calcium. For many years the pot method (see p. 104) was used exclusively, but it has been largely supplanted since calcium cyanide, ground to a fine granular form, became available at a relatively low cost. Where empty greenhouses are to be fumigated, the pot method is still recommended because of the higher concentration of poisonous gas obtainable by it. Calcium cyanide, when exposed to the air, reacts slowly with the moisture of the air and liberates the deadly gas slowly, thus giving a lower concentration over a longer period, so that there is less danger of injury to plants. This material was first used in Illinois as a greenhouse fumigant in 1923, and it is now quite generally used under the name of "Cyanogas" or "Calcyanide."

Calcium cyanide has great advantages over sodium or potassium cyanide, in that it requires no jars or pots, and no acid, and is less dangerous. Nevertheless, it should be handled as a very deadly poison. It should be kept in air-tight containers out of the reach of irresponsible

persons. The hands should be washed thoroughly after working with it. Extreme care should be taken not to breathe the fumes at any time.

Residents in dwellings connected to the greenhouse should vacate during fumigation with any form of cyanide, unless all the connecting doors are air-tight and the windows of the dwellings are kept open. When sodium or potassium cyanide is being used, it is *imperative* to vacate the house.

Signs warning people not to enter should be posted on the doors of the greenhouse during the period of fumigation.

Before fumigation is attempted, the houses should be made as tight as possible, and some means should be provided for opening the ventilators from the outside.

No form of cyanide should ever be used in houses where sweet peas, smilax, and asparagus are grown, since they are very susceptible to injury by it. Extreme caution must be taken also with snapdragon and spiraea.

Plants sprayed or dusted with Bordeaux mixture or other fungicides containing copper are almost sure to be severely injured by any form of cyanide fumigation. This fact cannot be over-emphasized.

All the plants to be fumigated with cyanide must be dry, since moisture on the foliage will absorb the gas and cause burning. The temperature should not be below 55° or above 70°F., and it should be rising, not falling, in order to prevent the formation of dew which would increase the danger of injury by burning. For the same reason, leaky steam pipes should be repaired before fumigation is undertaken, as the escaping steam may result in moisture collecting on the plants.

Never use cyanide in the daytime, for severe burning is almost sure to result. A clear night, when there is little or no wind, is best. The houses should be aired thoroughly the next morning, and it is not safe to enter the houses before they are aired.

In using *calcium cyanide*, it is best for the beginner to start with $\frac{1}{8}$ ounce per 1,000 cubic feet of space and increase the amount gradually until the desired results are obtained. For the control of greenflies, whiteflies, and most other insects, $\frac{1}{4}$ ounce per 1,000 cubic feet is the amount most generally used, but $\frac{1}{2}$ ounce may be used safely for the more hardy plants. These dosages are for an over-night exposure.

The calcium cyanide should be distributed evenly along the walks, taking the center walk in a house containing from four to six benches, and several walks in wider houses. Where several walks are to be treated, it is best to assign a man to each walk. The walks should not be watered, since moisture increases the danger of injury to the plants.

The cyanide is most easily distributed from pint or quart bottles having long, gradually tapering necks. Starting at the far end of the house and walking backward, allow the cyanide to run out in a thin stream on the walks. Take care not to allow bunching of the material.

The *pot method* of fumigation with *sodium cyanide* is preferred where heavy dosages are required, as in empty greenhouses, and it may be used successfully at any desired strength. Where calcium cyanide gives a slow evolution of gas, the pot method gives a rapid evolution within a very short time. When growing plants are to be fumigated by this method, the dosage generally used for an over-night exposure is $\frac{1}{8}$ to $\frac{1}{4}$ ounce per 1,000 cubic feet of space, though heavier dosages are sometimes used for one or two hours.

The plants should be dry, and the temperature should be between 55° and 70°F. Rising temperatures are preferred, since falling temperatures cause moisture to form on the leaves and increase the danger of injury. Do not attempt to fumigate before nightfall.

Materials required for fumigation with sodium cyanide by the pot method are as follows:

- (1) Half-gallon or gallon graniteware or earthenware crocks.
(The narrower and deeper crocks are to be preferred.)
- (2) Sodium cyanide, 98-99% pure.
- (3) Commercial sulfuric acid testing 66° Baume.
- (4) Glass graduate (8-16 ounces) for measuring liquids.
- (5) Accurate scales or balances. (Since cyanide is usually purchased as one-ounce "eggs," under the trade name of "Cyanegg," the scales may not be required.)
- (6) Paper bags.
- (7) Water.

The chemicals are used in the proportions of one ounce of cyanide, $1\frac{1}{2}$ ounces of sulfuric acid, and two ounces of water.

Place the jars or crocks in the center walks about 25 feet apart. Into each crock pour the required amount of water, i. e., two ounces for each ounce of cyanide to be used. Into a glass jar beside each crock pour the required amount of sulfuric acid, i. e., $1\frac{1}{2}$ ounces to each ounce of cyanide. Place the required amount of cyanide in a paper bag beside each crock. Then have a man ready to work each string of crocks. Let the men all start at the same time, at the far end of the house, and pour the acid into the water, slowly, at first, so as not to heat too rapidly. As soon as all crocks have been thus treated, let the men return to the far end of the house and drop the paper bags with the cyanide into the jars, moving quickly from jar to jar. As little time as possible should be lost after adding the acid to the water

until the job is finished. Then everyone should leave the house immediately, and the doors should be locked or plainly marked to warn against entering. Never let anyone enter the house until after it has been thoroughly aired.

After fumigation the residue left in the crocks should be buried in the ground and the crocks washed before they are put away. Wash the hands thoroughly after handling the cyanide.

Cautions in the use of sodium cyanide:

- (1) Make accurate determinations of the house contents and amounts of acid, water, and cyanide required.
- (2) Make sure the plants have not been sprayed or dusted with Bordeaux mixture or any other compound containing copper.
- (3) Make sure the plants are dry.
- (4) Do not use metal containers for handling acid, and do not splash it on clothing or skin.
- (5) Have a bottle of ammonia handy to apply to clothing or skin in case the acid is spilled.
- (6) Always pour the acid into the water, never the water into the acid.
- (7) Do not fumigate when the temperature in the house is below 55°F. or above 70°F. and do not allow the temperature to fall during fumigation.
- (8) Do not fumigate on windy or rainy nights or in daylight hours.
- (9) Do not fumigate with cyanide when the house adjoins a dwelling without seeing that the inhabitants vacate over night.
- (10) Keep the cyanide in air-tight containers and out of reach of persons not acquainted with its poisonous nature.
- (11) Cyanide is one of the most deadly poisons known, and the utmost care must be used in handling it.

Nicotine in one form or another is the most often used greenhouse fumigant. The nicotine gas is obtained by burning nicotine papers, cones, powders, or tobacco stems. Liquids containing free nicotine are often evaporated by painting on steam pipes or placing in cups provided for this purpose on the pipes. Good results are obtained with any of these forms, and the method used is largely determined by the preference of the grower. Since no two houses are the same in regard to tightness, the grower will best start with the directions given by the manufacturers and regulate the amount by the results obtained. Since nicotine papers, cones, and powders lose their strength after a time, it is not advisable to lay in large supplies.

Concentrated nicotine solutions are deadly poisons when taken internally, and the fumes are also injurious when inhaled in more than small quantities.

It is generally believed that long-continued and frequent fumigations with nicotine tend to produce a woody growth in plants. This is especially true in the case of roses. Nicotine fumigations are likely to burn or spot the blossoms of many plants, as stated under the crop headings in PART TWO of this circular.

Carbon bisulfide finds a limited use in greenhouses as a soil fumigant in the control of root aphids, ants, and other soil-inhabiting insects. Unless otherwise stated in the text, 1-inch holes are made in the soil 12 inches apart and half the depth of the soil in the raised bench or 10 to 12 inches deep in the ground bed. One tablespoonful of carbon bisulfide is poured into each hole, which should then be closed by tamping.

Carbon bisulfide is highly explosive and should be kept away from fires and open flames. The fumes are also poisonous to human beings.

Sulfur may be burned in the greenhouse between crops and *when the houses are empty*. It may often be used to advantage in thickly populated districts where the use of hydrocyanic acid gas is too dangerous. Sulfur fumes are very destructive to plant life as well as to insects and should never be used at all where plants are growing. There is danger of injury also to vegetation outside the greenhouse. Sulfur fumes are not entirely effective against some eggs and mites.

Flowers of sulfur may be burned, or sulfur candles may be used. Either form should be used at the rate of three to five pounds for 1,000 cubic feet of space. It is not necessary to determine accurately the cubical contents of the house for this work. Simply estimate the cubical contents, and be sure to use enough sulfur. The fumes of sulfur are not explosive.

INSECTICIDES

There are two general classes of insecticides, namely, stomach poisons and contact insecticides. Some insecticides, such as hellebore, may be effective either when taken internally by an insect or when merely making external contact with it. Stomach poisons are applied to plants that are attacked by chewing insects, or they may be mixed with poison baits, but they are of no avail against piercing and sucking insects. In general, contact insecticides must be directed against the body of the pest. The method by which an insect feeds helps to determine the proper insecticide to use.

STOMACH POISONS

Arsenate of lead is the standard insecticide for chewing insects. It is preferred to calcium arsenate and Paris green for application to greenhouse plants, since it is less likely to cause injury. It may be used as a spray or dust and may be combined with oil emulsions, sulfur, Bordeaux mixture, or other fungicides. Arsenate of lead is used at the rate of one to two pounds in 50 gallons of water, or—for smaller amounts—one ounce in two to three gallons of water.

A very useful *poison bait* is made by the following formula:

Bran	25 pounds
Molasses	2 quarts
Water	10 quarts
Sodium arsenite	½ pint
or	
Paris Green.....	1 pound
or	
Arsenate of Lead.....	2 pounds

If only a small amount of the bait is needed, use one-fifth of each quantity shown in the formula.

CONTACT INSECTICIDES

Nicotine is one form of contact insecticide used in the greenhouse. It may be purchased as 40% nicotine sulfate solution or as “free” nicotine. “Nikoteen” and “Nicofume” are examples of the latter. Such solutions may be used also for preparing nicotine oleate, and to a lesser extent for general spraying. Nicotine sulfate is used alone (one ounce in four to six gallons of water), or in combination with an oil emulsion smaller amounts may be used (½ ounce in six to eight gallons of spray).

Nicotine oleate stock is prepared as follows:

40% “free” nicotine.....	10 parts
Oleic acid (Red oil).....	7 parts
Water (preferably soft).....	17 parts

Homemade nicotine dust. Hydrated lime is used as the carrier for the nicotine when it is to be applied in the form of a dust. Large amounts of the dust may be mixed in a barrel having a tight cover. Place 47 pounds of hydrated lime in the barrel, pour three pounds of 40% nicotine sulfate over the lime, and add about 30 pebbles the size of an egg. Roll the barrel back and forth over the floor, or rotate it

by mounting it in a frame with a rod and crank. It should be turned at the rate of 35 or 40 revolutions per minute, not faster, in order to insure the most thorough mixing. An old revolving churn may be substituted for the barrel.

To mix the dust in small quantities, place six pounds of hydrated lime in a small keg or bucket having a tight-fitting lid. Pour six ounces of 40% nicotine sulfate over the lime. Place 12 to 15 pebbles the size of a walnut in the container, close the lid and rotate for about 10 minutes.

Upon opening the container, be careful not to breathe the fumes, as they contain a large amount of nicotine which may cause a severe headache or nausea.

It is best to mix the dust just before it is to be used. If for any reason this is impracticable the dust should be stored in tight containers as soon as it is mixed. If allowed to stand open to the air for any length of time, it will lose some of its strength, but it may be held in an air-tight container for a month or two without any great depreciation in insecticidal value.

"*Derrisol*," a commercial product derived from certain tropical derris plants, is highly toxic to soft-bodied insects. The action of the poison is first to paralyze and then to kill. Therefore, the full effect of the spray is not evident for several days. Derris is more pleasant to handle than nicotine extracts and is non-poisonous to man. It may be used with safety on all greenhouse plants at the dilutions recommended by the manufacturers.

Pyrethrum powder, also known as Persian or Dalmatian insect powder, or simply as insect powder, is made from the ground heads of pyrethrum plants. It is efficient against certain insects as described in the text. It may be used alone as a dust, or in solution at the rate of one ounce to one gallon of water. Precaution should be taken to obtain it freshly ground, since the powder deteriorates rapidly. Pyrethrum is not poisonous to man and the higher animals.

There are on the market numerous pyrethrum dusts, extracts, and soap extracts, which are efficient contact insecticides. Each one should be used at the dilutions recommended by the manufacturers.

Oil emulsions are coming into general use for the spraying of greenhouse plants. The light oil emulsions, of which "*Verdol*" and "*Volck*" are examples, are safe to use on plants when properly mixed and diluted. They may be used in combination with arsenate of lead, nicotine, derris, etc., but must never be mixed with sulfur or sulfur compounds nor sprayed on plants containing sulfur. Neither should they be used if free oil shows on the surface.

Boiled lubricating-oil emulsion may be purchased from manufacturers of insecticides or from mail-order houses, or may be made by the greenhouse operator according to the following formula:

Paraffin oil*	1 gallon
Water (preferably soft)	1 quart
Potash fish-oil soap	2 pounds

The water, soap, and oil are placed in a kettle or other receptacle and heated to the boiling point. Boil the mixture for about two minutes, being careful not to burn it. Remove it from the fire and run it twice through a bucket pump. Do not allow the mixture to cool before pumping. A barrel pump may be used for making larger amounts of the emulsion. A properly made stock emulsion will keep for a considerable time but should not be allowed to freeze.

Kerosene emulsion is not recommended for spraying plants in the greenhouse, but it affords a cheap and effective spray for destroying pests in the empty benches, under the benches, or on the walks. It is prepared by mixing kerosene, soap, and water in the following proportions:

Fish-oil soap or laundry soap	½ pound
Kerosene	2 gallons
Water (preferably soft)	1 gallon

Shave the soap and dissolve in hot water. While still hot, add the kerosene and mix thoroughly with a bucket pump or any similar hand pump, for about five minutes, or until all the liquid has passed through the pump three times.

This emulsion will deteriorate with age, and if it shows free oil on the surface it should not be used until reheated and emulsified.

Orthodichlorobenzene emulsion is prepared in the same manner as kerosene emulsion, using the formula:

Orthodichlorobenzene	1 gallon
Soap (fish-oil or laundry)	2 pounds
Water (preferably soft)	1 quart

Nicotine powder, made by grinding parts of the tobacco plant, is used for the control of rose midge and other soil-infesting insects. It should contain about 1% actual nicotine. Powders containing less than this amount are of little or no value as insecticides.

*Or any oil with the following approximate requirements: specific gravity 0.886, viscosity 265.3, volatility 4.9%.

Dusting sulfur is recommended as a diluent for other poisons used as dusts. It is an excellent carrier and also acts as a fungicide.

Lime-sulfur is used in the greenhouse as a spray. (See text, p. 25.)

APPLIANCES

Dusting in the greenhouse for the control of insects is rapidly coming into extensive use. In general dusts can be applied more thoroughly and quickly than sprays, and their residues are more easily washed off the plants.

Hand dusters are best adapted for this work. Either the blower type or the puff type is quite satisfactory. The essential requirements of a hand duster are:

- (1) It should throw a uniform charge of dust with driving force.
- (2) It should have adjustments for regulating the flow.
- (3) It should be compact, to allow for operating in the narrow greenhouse walk.
- (4) It should have no projections that may catch in the plants and cause injury.
- (5) The driving mechanism should be easily accessible for replacement of worn parts and for oiling.

Small hand dusters of the plunger and cylinder type can often be used to advantage where a small number of plants are to be treated.

Forced ventilation in the past few years has shown promise of practical application in the greenhouse. The writer has had occasion to try this method of distributing dusts and has obtained excellent distribution on the plants by simply pouring the dust into the ventilating machine.

Hand sprayers are recommended for small establishments and for houses where a variety of plants are grown. The compressed-air type with a capacity of one to four gallons is easily carried and successfully operated. Larger sprayers of this type, holding 10 to 25 gallons, are mounted on wheels. All hand sprayers should be capable of maintaining a pressure of 100-150 pounds. The outfit should be narrow enough to be wheeled between the benches and short enough to allow for turning corners in a small space. It should be equipped with nozzles of the angle type, to permit spraying the underside of the leaves. An extension rod three or four feet in length will be found very helpful.

After being used, the sprayer should always be thoroughly washed with clear water to prevent unnecessary corrosion and clogging of nozzles.

Power sprayers are frequently used to advantage in a large establishment or where a single crop is grown. In this case the outfit is stationary, located near the center of the range. It consists of an electric or gasoline motor, a pump, and a large tank for holding the spray material. Pipes are run from the pump to convenient points in the range and connected with 25 to 50 feet of hose for spraying. The amount of material lost by being left in the pipes is small compared with the convenience and saving in labor (1,000 feet of 1-inch pipe holds approximately 40 gallons of liquid). By using shut-off valves at the conducting main, it is not necessary to fill all the pipes with each spraying. The pipes should be flushed with clear water after each spraying.

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